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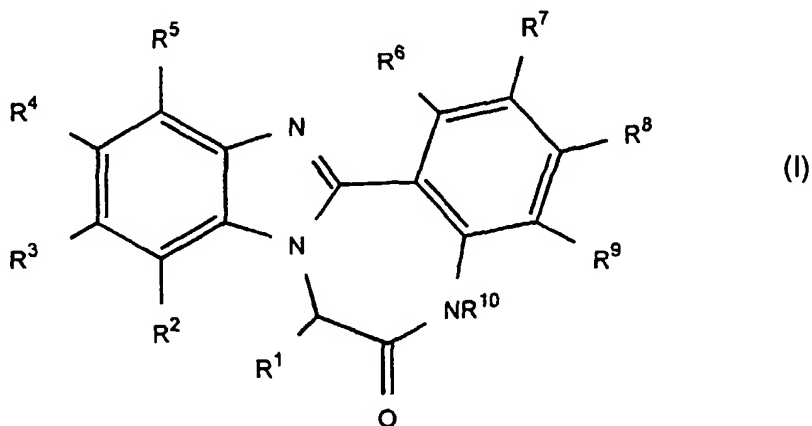
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(54) Title: TETRACYCLIC BENZIMIDAZOLE DERIVATIVES AND COMBINATORIAL LIBRARIES THEREOF



(57) Abstract: The present invention relates to novel tetracyclic benzimidazole derivative compounds of formula (I) wherein R¹ to R¹⁰ have the meanings provided herein. The invention further relates to combinatorial libraries containing two or more such compounds, as well as methods of preparing tetracyclic benzimidazole derivative compounds.

**TETRACYCLIC BENZIMIDAZOLE DERIVATIVES
AND COMBINATORIAL LIBRARIES THEREOF**

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

5 The present invention relates generally to the
synthesis of compounds comprising heterocyclic rings. In
one specific embodiment, the invention provides novel
tetracyclic benzimidazole derivative compounds as well as
novel combinatorial libraries comprised of such
10 compounds.

BACKGROUND INFORMATION

The process of discovering new therapeutically
active compounds for a given indication involves the
screening of all compounds from available compound
15 collections. From the compounds tested, one or more
structures is selected as a promising lead. A large
number of related analogs are then synthesized in order
to develop a structure-activity relationship and select
one or more optimal compounds. With traditional "one-at-
20 a-time" synthesis and biological testing of analogs, this
optimization process is long and labor intensive. Adding
significant numbers of new structures to the compound
collections used in the initial screening step of the
discovery and optimization process cannot be accomplished
25 with traditional "one-at-a-time" synthesis methods,
except over a time frame of years or even decades.
Faster methods are needed that allow for the preparation
of up to thousands of related compounds in a matter of
days or a few weeks. This need is particularly evident
30 when it comes to synthesizing more complex compounds,
such as tetracyclic benzimidazole derivative compounds.

Combinatorial approaches have recently been extended to "organic," or non-peptide, libraries. For example, Zambias et al. (U.S. Patent No. 5,712,171) describe a method of generating libraries that contain
5 aminimides, oxazolones, sulfonylaminides and phosphonylaminides as the core structure in spatially arranged arrays. Combinatorial chemical methods have been applied to a limited number of heterocyclic compounds, as described, for example, in Wilson et al.,
10 *Molecular Diversity*, 3:95-112 (1998); U.S. Patent Nos. 5,288,514; 5,324,483; and Goff et al., *J. Org. Chem.*, 60:5748-5749 (1995). See also U.S. Patent Nos. 5,549,974 and 5,506,337. Combinatorial chemical methods have even been extended to benzimidazole compounds, as described,
15 for example, in Tumelty et al., *Tetr. Ltrs.*, 40:6185-6188 (1999); Yeh et al., *Synlett*, 6:810-812 (1999); Sun et al., *Bioorg. & Med. Chem. Ltrs.*, 8:361-364 (1998); Huang et al., *Tetr. Ltrs.*, 40:2665-2668 (1999); Phillips and Wei, *Tetr. Ltrs.*, 37:4887-4890 (1996); and Mayer et al.,
20 *Tetr. Ltrs.*, 39:6655-6658 (1998). However, the heterocyclic libraries to date contain compounds of limited diversity and complexity.

Substituent limitations have been overcome for mixtures of peptides and peptidomimetics through the use
25 of solid phase techniques versus solution-phase. An important step in the development of solid-phase techniques was the discovery of methods to prepare large numbers of individual compounds simultaneously, as described, for example, by Houghten in U.S. Patent No.
30 4,631,211. These solid phase methods, however, have rarely been applied to the syntheses of complex heterocyclic structures. Therefore a need exists to develop more complex "organic" libraries based on heterocyclic medicinal compounds which would need less

time and effort in the synthesis and testing required to bring an organic pharmaceutical product to fruition. In short, improved methods for generating therapeutically useful heterocyclic compounds, such as tetracyclic benzimidazole derivatives, are desired.

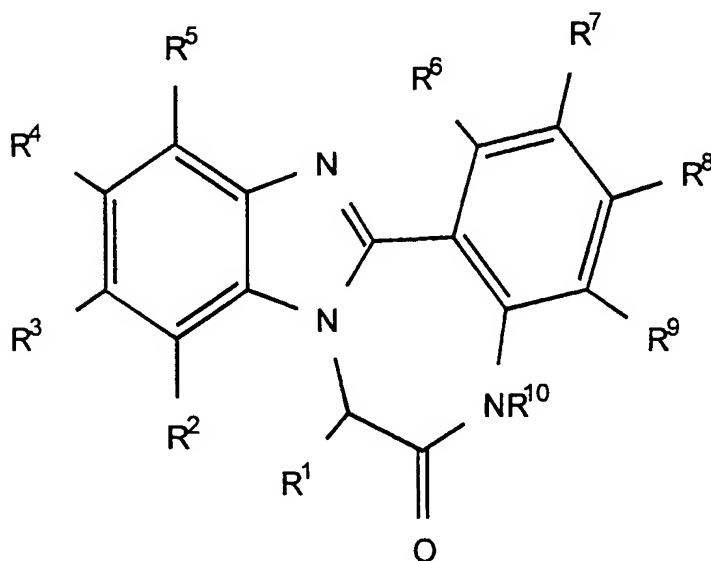
Tetracyclic benzimidazole derivative compounds have been the subject of investigation in a number of different biological areas. For example, tetracyclic benzimidazole derivatives have been proposed as useful as antidepressants (DE 2051962 (1971)). Tetracyclic benzimidazole derivatives have also been the subject of serial chemical synthesis. See, for example, DE 2051962 (1971); Herkaoui et al., *Synth. Commun.*, 25:3287-92 (1995); Herkaoui et al., *Synth. Commun.*, 25:1027-33 (1995); and Duncan et al., *J. Heterocycl. Chem.*, 10:65-70 (1973). However, more complex benzimidazole derivatives, especially those that are tetracyclic and, more especially, those that have a substituent other than hydrogen have been difficult to attain.

This invention satisfies this need and provides related advantages as well. The present invention overcomes the known limitations to classical serial organic synthesis of tetracyclic benzimidazole derivatives, for example, as well as the shortcomings of combinatorial chemistry related to tetracyclic benzimidazole derivatives. The present invention allows for rapid generation of large diverse libraries of complex tetracyclic benzimidazole derivatives as discrete molecules. The present invention can utilize a readily available pool of building blocks that can be incorporated into the various regions of the molecule. Furthermore, the method of making the present invention allows for the use of building blocks that contain a wide

range of diverse functionality. Such building blocks can provide combinatorial libraries that consist of large numbers as well as combinatorial libraries that are extremely diverse with respect to the functionality
5 contained within those libraries. The present invention combines the techniques of solid-phase synthesis of tetracyclic benzimidazole derivatives and the general techniques of synthesis of combinatorial libraries to prepare highly diverse new tetracyclic benzimidazole
10 derivative compounds.

SUMMARY OF THE INVENTION

The present invention relates to novel tetracyclic benzimidazole derivative compounds of the following formula:



15 wherein R¹ to R¹⁰ have the meanings provided below.

The invention further relates to combinatorial libraries containing two or more such compounds, and to

methods of generating tetracyclic benzimidazole derivative compounds.

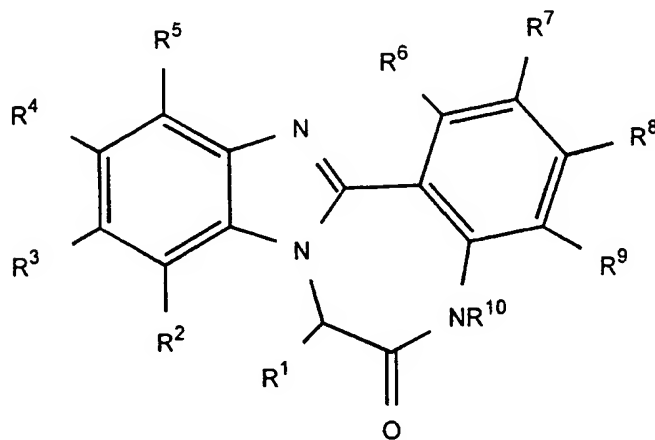
BRIEF DESCRIPTION OF THE DRAWING

In Figure 1, described below, as well as the
5 examples, R^1 corresponds to R^1 of the claimed invention;
 R^2 corresponds to R^2 to R^5 of the claimed invention;
 $-C(O)NHR^2$ corresponds to R^4 of the claimed invention
(which can be $-C(O)NR^{11}R^{12}$); and $-NHR^3$ and $-SR^3$ correspond
to R^7 of the claimed invention (which can be $-NR^{11}R^{12}$ or
10 $-SR^{11}$).

Figure 1 shows the reaction scheme for the
combinatorial synthesis of tetracyclic benzimidazole
derivative compounds.

DETAILED DESCRIPTION OF THE INVENTION

15 The present invention provides compounds and
combinatorial libraries of compounds of the formula:



wherein:

R^1 is a hydrogen atom, C_1 to C_{12} alkyl, C_1 to C_{12}
 substituted alkyl, phenyl, substituted phenyl, C_7 to C_{18}
 phenylalkyl, C_7 to C_{18} substituted phenylalkyl, C_1 to C_{12}
 heterocycloalkyl, C_1 to C_{12} substituted heterocycloalkyl,
 5 heteroaryl, substituted heteroaryl, cyano, C_1 to C_{12} acyl,
 C_1 to C_{12} substituted acyl, C_1 to C_{12} alkoxycarbonyl, C_1 to
 C_{12} substituted alkoxycarbonyl, C_1 to C_{12}
 alkylaminocarbonyl, C_1 to C_{12} substituted
 alkylaminocarbonyl, phenylaminocarbonyl, substituted
 10 phenylaminocarbonyl, C_1 to C_{10} alkylthio, C_1 to C_{10}
 substituted alkylthio, C_1 to C_{10} alkylsulfonyl, C_1 to C_{10}
 substituted alkylsulfonyl, C_1 to C_{10} alkylsulfoxide, C_1 to
 C_{10} substituted alkylsulfoxide, phenylthio, substituted
 phenylthio, phenylsulfoxide, substituted phenylsulfoxide,
 15 phenylsulfonyl, substituted phenylsulfonyl, heterocycle,
 substituted heterocycle, cyclic C_2 to C_7 alkylene,
 substituted cyclic C_2 to C_7 alkylene, cyclic C_2 to C_7
 heteroalkylene, substituted cyclic C_2 to C_7
 heteroalkylene, naphthyl, substituted naphthyl, C_5 to C_7
 20 cycloalkyl, C_5 to C_7 substituted cycloalkyl, C_5 to C_7
 cycloalkenyl or C_5 to C_7 substituted cycloalkenyl;

R^2 , R^3 , R^4 , R^5 , R^6 , R^7 , R^8 and R^9 are, independently, a
 hydrogen atom, halo, hydroxy, protected hydroxy, cyano, C_1
 to C_{12} alkyl, C_2 to C_{12} alkenyl, C_2 to C_{12} alkynyl, C_1 to C_{12}
 25 substituted alkyl, C_2 to C_{12} substituted alkenyl, C_2 to C_{12}
 substituted alkynyl, C_1 to C_{12} alkoxy, C_1 to C_{12} substituted
 alkoxy, C_1 to C_{12} acyloxy, C_1 to C_{12} acyl, C_3 to C_7
 cycloalkyl, C_3 to C_7 substituted cycloalkyl, C_5 to C_7
 cycloalkenyl, C_5 to C_7 substituted cycloalkenyl,
 30 heterocyclic ring, substituted heterocyclic ring, C_7 to
 C_{18} phenylalkyl, C_7 to C_{18} substituted phenylalkyl, C_1 to
 C_{12} heterocycloalkyl, C_1 to C_{12} substituted
 heterocycloalkyl, phenyl, substituted phenyl, naphthyl,
 substituted naphthyl, cyclic C_2 to C_7 alkylene,

- substituted cyclic C₂ to C₇ alkylene, cyclic C₂ to C₇,
heteroalkylene, substituted cyclic C₂ to C₇,
heteroalkylene, carboxy, protected carboxy,
hydroxymethyl, protected hydroxymethyl, amino, protected
5 amino, (monosubstituted)amino, protected
(monosubstituted)amino, (disubstituted)amino, C₁ to C₁₀
alkylamino, C₁ to C₁₀ alkyl protected amino, C₁ to C₁₀ alkyl
(monosubstituted)amino, C₁ to C₁₀ alkyl, protected
(monosubstituted)amino, C₁ to C₁₀
10 alkyl(disubstituted)amino, C₁ to C₁₀ substituted
alkylamino, C₁ to C₁₀ substituted alkyl protected amino, C₁
to C₁₀ substituted alkyl (monosubstituted)amino, C₁ to C₁₀
substituted alkyl protected (monosubstituted)amino, C₁ to
C₁₀ substituted alkyl(disubstituted)amino, carboxamide,
15 protected carboxamide, C₁ to C₁₀ alkylthio, C₁ to C₁₀
substituted alkylthio, C₁ to C₁₀ alkylsulfonyl, C₁ to C₁₀
substituted alkylsulfonyl, C₁ to C₁₀ alkylsulfoxide, C₁ to
C₁₀ substituted alkylsulfoxide, phenylthio, substituted
phenylthio, phenylsulfoxide, substituted phenylsulfoxide,
20 phenylsulfonyl, substituted phenylsulfonyl or (i) the
formula -C(O)NR¹¹R¹², (ii) the formula -C(O)R¹¹, (iii) the
formula -NR¹¹R¹², (iv) the formula -SR¹¹, (v) the formula
-OR¹¹ or (vi) the formula -C(O)OR¹¹, wherein R¹¹ and R¹² are,
independently, a hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂
25 substituted alkyl, C₂ to C₁₂ alkenyl, C₂ to C₁₂ substituted
alkenyl, phenyl, substituted phenyl, naphthyl,
substituted naphthyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈
substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁ to
C₁₂ substituted heterocycloalkyl, heteroaryl, substituted
30 heteroaryl, heterocycle, substituted heterocycle, C₁ to
C₁₂ acyl, C₁ to C₁₂ substituted acyl, phenylsulfonyl,
substituted phenylsulfonyl, C₁ to C₁₀ alkylsulfonyl, C₁ to
C₁₀ substituted alkylsulfonyl, C₁ to C₁₂
alkylaminocarbonyl, C₁ to C₁₂ substituted

alkylaminocarbonyl, phenylaminocarbonyl or substituted phenylaminocarbonyl; and

R¹⁰ is a hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, C₂ to C₁₂ alkenyl, C₂ to C₁₂ substituted
5 alkenyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈ substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl or C₁ to C₁₂ substituted heterocycloalkyl; or

a pharmaceutically acceptable salt of a compound thereof.

In an additional embodiment,

10 R¹ is a hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, phenyl, substituted phenyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈ substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁ to C₁₂ substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, C₁ to C₁₀ alkylthio, C₁
15 to C₁₀ substituted alkylthio, heterocycle or substituted heterocycle.

In a further embodiment,

R², R³, R⁴ and R⁵ are, independently, a hydrogen atom, halo, hydroxy, protected hydroxy, cyano, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, C₁ to C₁₂ alkoxy, C₁ to C₁₂ substituted alkoxy, carboxy, protected carboxy, C₁ to C₁₀ alkylthio, C₁ to C₁₀ substituted alkylthio, the formula
20 -C(O)NR¹¹R¹² or the formula -C(O)R¹¹, wherein R¹¹ and R¹² join the nitrogen atom depicted in the above formula to form a heterocycle or substituted heterocycle or R¹¹ and R¹² are, independently, a hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, phenyl, substituted phenyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈ substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁ to C₁₂ substituted

heterocycloalkyl, heteroaryl, substituted heteroaryl, heterocycle or substituted heterocycle.

In another embodiment,

5 R^2 , R^3 , and R^5 are each a hydrogen atom, and R^4 is the formula $-C(O)NR^{11}R^{12}$ or the formula $-C(O)R^{11}$, wherein R^{11} and R^{12} join the nitrogen atom depicted in the above formula to form a heterocycle or substituted heterocycle or R^{11} and R^{12} are, independently, a hydrogen atom, C_1 to C_{12} alkyl, C_1 to C_{12} substituted alkyl, phenyl, substituted
10 phenyl, C_7 to C_{18} phenylalkyl, C_7 to C_{18} substituted phenylalkyl, C_1 to C_{12} heterocycloalkyl, C_1 to C_{12} substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, heterocycle or substituted heterocycle.

In a further embodiment,

15 R^6 , R^7 , R^8 and R^9 are, independently, a hydrogen atom, halo, heterocycle, substituted heterocycle the formula $-NR^{11}R^{12}$ or the formula $-SR^{11}$, wherein R^{11} and R^{12} are, independently, a hydrogen atom, C_1 to C_{12} alkyl, C_1 to C_{12} substituted alkyl, C_2 to C_{12} alkenyl, C_2 to C_{12} substituted
20 alkenyl, C_7 to C_{18} phenylalkyl, C_7 to C_{18} substituted phenylalkyl, C_1 to C_{12} heterocycloalkyl, C_1 to C_{12} substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, heterocycle or substituted heterocycle.

In an additional embodiment,

25 R^6 , R^8 and R^9 are each a hydrogen atom, and R^7 is halo, heterocycle, substituted heterocycle, the formula $-NR^{11}R^{12}$ or the formula $-SR^{11}$, wherein R^{11} and R^{12} are, independently, a hydrogen atom, C_1 to C_{12} alkyl, C_1 to C_{12} substituted alkyl, C_2 to C_{12} alkenyl, C_2 to C_{12} substituted

alkenyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈ substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁ to C₁₂ substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, heterocycle or substituted heterocycle.

5 In another embodiment, R¹⁰ is a hydrogen atom.

Another embodiment provides that

R¹ is a hydrogen atom, methyl, 2-propyl, 2-butyl, aminocarbonyl ethyl, 2-methylmercaptoethyl, phenyl, benzyl, cyclohexylmethyl, 4-methoxybenzyl,
10 4-chlorobenzyl, 3-indolylmethyl, 4-(trifluoroacetyl)aminobutyl or 3-guanidinopropyl;

R², R³, R⁵, R⁶, R⁸, R⁹ and R¹⁰ are each a hydrogen atom;

R⁴ is the formula -C(O)NR¹¹R¹², wherein R¹¹ and R¹² join the nitrogen atom in the depicted formula to form one of the
15 following substituents: 1-pyrrolidino, 4-methyl-1-homopiperazino, 4-(4-fluorophenyl)-1-piperazino, 4-(2-hydroxyethoxyethyl)-1-piperazino, 4-(2-pyridyl)-1-piperazino, 4-hydroxy-1-piperidino,
20 4-amino-2,2,6,6-tetramethyl-1-piperidino, 3-ethoxycarbonyl-1-piperidino, 4-(4-methoxyphenyl)-3-methyl-1-piperazino, 4-aminocarbonyl-1-piperidino, heptamethyleneimino, 4-(2-furoyl)-1-piperazino,
25 4-(3-trifluoromethylphenyl)-1-piperazino, 3-acetamido-1-pyrrolidino, 4-ethoxycarbonyl-1-piperazino, 4-ethoxycarbonyl-1-piperidino or 4-thiomorpholino, or R¹¹ and R¹² are, independently, a hydrogen atom, (1-ethyl-2-pyrrolidinyl)methyl, 2-thiazolyl,

5-methoxycarbonylpentyl, 2-ethoxycarbonylethyl,
3-(methylthio)phenyl, N-methyl-(1-methyl-4-piperidino),
2-(pyridin-2-yl)ethyl, 2-hydroxyethyl,
4-(trifluoromethyl)benzyl, N,N-dimethylaminoethyl,
5 3-(2-oxo-1-pyrrolidino)propyl,
1-ethoxycarbonyl-4-piperidino, pyridin-2-ylmethyl,
bis(2-methoxyethyl), 2-acetylaminoethyl,
3-(methylthio)propyl, 2-(1-morpholino)ethyl, 5-indazolyl,
cyclopropyl, N-ethyl-(pyridin-4-ylmethyl), cyclopentyl,
10 cycloheptyl, pyridin-3-ylmethyl,
4-(trifluoromethyl)benzyl, 2-(thien-2-yl)ethyl,
3-(N-pyrrolidino)propyl or 3-(1-imidazolyl)propyl;

R⁷ is cyclopropylamino, 2-(1-morpholino)ethylamino,
piperazino, 2-methyl-4-(3-methylphenyl)-1-piperazino,
15 4-aminocarbonylpiperidino, 2-(pyridin-2-yl)ethylamino,
2-(N,N-dimethylamino)ethylamino,
3-(aminomethyl)benzylamino,
(5-phenyl-1H-1,2,4-triazol-3-yl)thio,
3-(4-morpholino)propylamino, tetrahydrofurfurylamino,
20 4-(2,5-dimethylphenyl)-1-piperazino, hexamethyleneimino,
N-methyl-2-(pyridin-2-yl)ethylamino,
2-(dimethylamino)ethylamino, 4-(aminomethyl)benzylamino,
(3-carboxypyridin-6-yl)thio, 2-acetylaminoethylamino,
2-(ethoxycarbonyl)ethylamino,
25 4-(2,3-dimethylphenyl)-1-piperazino,
4-(2-pyridyl)-1-piperazino, 3-(2-pipecolino)propylamino,
2-aminoethylamino, cyclohexylamino, imidazol-2-ylthio,
4-ethoxycarbonyl-1-piperazino, 3-methylthiopropylamino,
4-(4-fluorophenyl)piperazino,
30 1-benzyl-3-pyrrolidinoamino, N-methyl-4-piperidylamino,
3-aminopropylamino, N-benzylmethylamino,
(3,5-dimethyl-2,6-pyrimidin-2-yl)thio,
4-acetyl-1-piperazino, 2,3-dimethoxybenzylamino,
4-(3,4-dichlorophenyl)-1-piperazino,

- 3-ethoxycarbonyl-1-piperidino, pyridin-3-ylmethylamino,
N-methyl-2-(diethylamino)ethylamino,
N-methylphenethylamino,
(5-methyl-1,3,4-thiadiazol-2-yl)thio,
5 8-amino-3,6-dioxaoctylamino, 3-acetamido-1-pyrrolidino,
4-benzyl-1-piperazino, 4-ethoxycarbonyl-1-piperazino,
2-piperadinoethylamino, 3-dimethylaminopropylamino,
cycloheptylamino, (1H-1,2,4-triazol-3-yl)thio,
4-ethoxycarbonylmethyl-1-piperazino,
10 4-(diethylamino)-2-butenylamino,
4-(4-nitrophenyl)-1-piperazino,
1-ethoxycarbonyl-4-piperidylamino,
1-benzyl-4-piperidylamino,
N-methyl-3-(dimethylamino)propylamino,
15 4-(trifluoromethyl)benzylamino,
(4-methyl-1,2,4-triazol-3-yl)thio, 2-ethoxyethylamino,
tyramino, 4-(3-trifluoromethylphenyl)-1-piperazino,
1,3,3-trimethyl-6-aza-6-bicyclo(3,2,1)octyl,
3,3'-bis(dimethylamino)dipropylamino, butylamino,
20 3-(trifluoromethyl)benzylamino, pyridin-2-ylthio,
4-(2-furoyl)-1-piperazino, cyclooctylamino,
4-(4-acetylphenyl)-1-piperazino,
4-(4-methylphenyl)-3-methyl-1-piperazino,
2-fluorophenethylamino, 3-fluorophenethylamino,
25 4-fluorobenzylamino, fluoro, morpholino, thiomorpholino,
4-(5-chloro-2-methylphenyl)-1-piperazino,
(1-ethyl-2-pyrrolidino)methylamino,
2,2,6,6-tetramethyl-4-piperidylamino, diethylamino or
3,3,5-trimethylcyclohexylamino.

30 In a further embodiment,

R¹ is a hydrogen atom, methyl, 2-propyl, 2-butyl,
aminocarbonyl ethyl, 2-methylmercaptoethyl, phenyl,
benzyl, cyclohexylmethyl, 4-methoxybenzyl,

4-chlorobenzyl, 3-indolylmethyl,
4-(trifluoroacetyl)aminobutyl or 3-guanidinopropyl;

R², R³, R⁴ and R⁵ are, independently, a hydrogen atom,
methyl, carboxy, bromo, fluoro, chloro or
5 trifluoromethyl;

R⁶, R⁶, R⁹ and R¹⁰ are each a hydrogen atom; and

R⁷ is cyclopropylamino, 2-(1-morpholino)ethylamino,
piperazino, 2-methyl-4-(3-methylphenyl)-1-piperazino,
4-aminocarbonylpiperidino, 2-(pyridin-2-yl)ethylamino,
10 2-(N,N-dimethylamino)ethylamino,
3-(aminomethyl)benzylamino,
(5-phenyl-1H-1,2,4-triazol-3-yl)thio,
3-(4-morpholino)propylamino, tetrahydrofurfurylamino,
4-(2,5-dimethylphenyl)-1-piperazino, hexamethyleneimino,
15 N-methyl-2-(pyridin-2-yl)ethylamino,
2-(dimethylamino)ethylamino, 4-(aminomethyl)benzylamino,
(3-carboxypyridin-6-yl)thio, 2-acetylaminomethylamino,
2-(ethoxycarbonyl)ethylamino,
4-(2,3-dimethylphenyl)-1-piperazino,
20 4-(2-pyridyl)-1-piperazino, 3-(2-pipecolino)propylamino,
2-aminoethylamino, cyclohexylamino, imidazol-2-ylthio,
4-ethoxycarbonyl-1-piperazino, 3-methylthiopropylamino,
4-(4-fluorophenyl)piperazino,
1-benzyl-3-pyrrolidinoamino, N-methyl-4-piperidylamino,
25 3-aminopropylamino, N-benzylmethylamino,
(3,5-dimethyl-2,6-pyrimidin-2-yl)thio,
4-acetyl-1-piperazino, 2,3-dimethoxybenzylamino,
4-(3,4-dichlorophenyl)-1-piperazino,
3-ethoxycarbonyl-1-piperidino, pyridin-3-ylmethylamino,
30 N-methyl-2-(diethylamino)ethylamino,
N-methylphenethylamino,
(5-methyl-1,3,4-thiadiazol-2-yl)thio,

- 8-amino-3,6-dioxaoctylamino, 3-acetamido-1-pyrrolidino,
4-benzyl-1-piperazino, 4-ethoxycarbonyl-1-piperazino,
2-piperadinoethylamino, 3-dimethylaminopropylamino,
cycloheptylamino, (1H-1,2,4-triazol-3-yl)thio,
5 4-ethoxycarbonylmethyl-1-piperazino,
4-(diethylamino)-2-butenylamino,
4-(4-nitrophenyl)-1-piperazino,
1-ethoxycarbonyl-4-piperidylamino,
1-benzyl-4-piperidylamino,
10 N-methyl-3-(dimethylamino)propylamino,
4-(trifluoromethyl)benzylamino,
(4-methyl-1,2,4-triazol-3-yl)thio, 2-ethoxyethylamino,
tyramino, 4-(3-trifluoromethylphenyl)-1-piperazino,
1,3,3-trimethyl-6-aza-6-bicyclo(3,2,1)octyl,
15 3,3'-bis(dimethylamino)dipropylamino, butylamino,
3-(trifluoromethyl)benzylamino, pyridin-2-ylthio,
4-(2-furoyl)-1-piperazino, cyclooctylamino,
4-(4-acetylphenyl)-1-piperazino,
4-(4-methylphenyl)-3-methyl-1-piperazino,
20 2-fluorophenethylamino, 3-fluorophenethylamino,
4-fluorobenzylamino, fluoro, morpholino, thiomorpholino,
4-(5-chloro-2-methylphenyl)-1-piperazino,
(1-ethyl-2-pyrrolidino)methylamino,
2,2,6,6-tetramethyl-4-piperidylamino, diethylamino or
25 3,3,5-trimethylcyclohexylamino.

In any of the above embodiments, R⁷ can be present, i.e., not hydrogen. Additionally, in any of the above embodiments, R⁴ can be present, i.e., not hydrogen.

The invention also provides methods for making
30 tetracyclic benzimidazole derivative compounds and libraries. In one method of the invention, tetracyclic benzimidazole derivative compounds can be prepared by:

- (a) coupling a first compound having a substituent of the formula $\text{-NH-C(O)-C(variable group)-NH}_2$ with a phenyl compound that is substituted with a nitro group and a halo group in an ortho relationship on the phenyl ring,
- 5 the phenyl compound further optionally substituted with a variable group at one of the remaining 4 positions of the phenyl ring, resulting in a phenyl compound substituted with a nitro group and a monosubstituted amino group;
- (b) reducing the nitro group of the phenyl compound
- 10 resulting from step (a);
- (c) coupling the compound resulting from step (b) with a phenyl compound that is substituted with an aldehyde group and a nitro group in a meta relationship on the phenyl ring, the phenyl ring also being optionally
- 15 substituted with one or more leaving groups at one or more of the remaining 4 positions of the phenyl ring, resulting in a phenyl substituted benzimidazole derivative compound having a nitro substituted phenyl substituent; and
- 20 (d) reducing the nitro group of the benzimidazole derivative compound resulting from step (c) to form a five carbon two nitrogen seven-member ring, resulting in a tetracyclic benzimidazole compound.

In another method of the invention, the first

25 compound having a substituent of the formula $\text{-NH-C(O)-C(variable group)-NH}_2$ is attached to solid support.

In a further method of the invention, the variable group on the phenyl group in step (a) is a carboxyl.

30 Another method of the invention provides that the carboxyl group of the phenyl compound resulting from step (a) is coupled with a monosubstituted amine

compound, a disubstituted amine compound, a cyclic imino compound or an alcohol, resulting, respectively, in (i) a monosubstituted carboxamido substituent attached to the phenyl compound; (ii) a disubstituted substituent
5 carboxamido attached to the phenyl compound; (iii) a cyclic imino carbonyl substituent attached to the phenyl compound; or (iv) an ester substituent attached to the phenyl compound.

In a further method of the invention, the
10 leaving group of the phenyl substituted benzimidazole derivative compound resulting from step (c) is displaced with a (i) a monosubstituted amine; (ii) a disubstituted amine; (iii) a monosubstituted thiol; (iii) a cyclic imine; (iv) a cyclic thiol; or (v) an alcohol, resulting,
15 respectively, in a monosubstituted amino, disubstituted amino, cyclic imino, cyclic thio, monosubstituted thio or ether moiety on the phenyl ring.

When the above-described compounds include one or more chiral centers, the stereochemistry of such
20 chiral centers can independently be in the R or S configuration, or a mixture of the two. The chiral centers can be further designated as R or S or R,S or d,D, l,L or d,l, D,L.

Regarding the compounds and combinatorial
25 libraries described herein, the suffix "ene" added to any of the described terms means that two parts of the substituent are each connected to two other parts in the compound (unless the substituent contains only one carbon, in which case such carbon is connected to two
30 other parts in the compound, for example, methylene).

The term " C_1 to C_{12} alkyl" denotes such radicals as methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, tert-butyl, amyl, tert-amyl, hexyl, heptyl, octyl, nonyl, decyl, undecyl, dodecyl and the
5 like. Preferred " C_1 to C_{12} alkyl" groups are methyl, ethyl, iso-butyl, sec-butyl and iso-propyl. Similarly, the term " C_1 to C_{12} alkylene" denotes radicals of 1 to 12 carbons connected to two other parts in the compound.

The term " C_2 to C_{12} alkenyl" denotes such
10 radicals as vinyl, allyl, 2-butenyl, 3-butenyl, 2-pentenyl, 3-pentenyl, 4-pentenyl, 2-hexenyl, 3-hexenyl, 4-hexenyl, 5-hexenyl, 2-heptenyl, 3-heptenyl, 4-heptenyl, 5-heptenyl, 6-heptenyl, (as well as octenyl, nonenyl, decenyl, undecenyl, dodecenyl radicals attached at any
15 appropriate carbon position and the like) as well as dienes and trienes of straight and branched chains.

The term " C_2 to C_{12} alkynyl" denotes such radicals as ethynyl, propynyl, 2-butyne, 2-pentyne, 3-pentyne, 2-hexyne, 3-hexyne, 4-hexyne, 2-heptyne,
20 3-heptyne, 4-heptyne, 5-heptyne (as well as octyne, nonyne, decyne, undecyne, dodecyne radicals attached at any appropriate carbon position and the like) as well as di- and tri-ynes of straight and branched chains.

The terms " C_1 to C_{12} substituted alkyl," " C_2 to
25 C_{12} substituted alkenyl," " C_2 to C_{12} substituted alkynyl," " C_1 to C_{12} substituted alkylene," " C_2 to C_{12} substituted alkenylene" and " C_2 to C_{12} substituted alkynylene" denote groups are substituted by one or more, and preferably one or two, halogen, hydroxy, protected hydroxy, oxo,
30 protected oxo, C_3 to C_7 cycloalkyl, phenyl, naphthyl, amino, protected amino, (monosubstituted)amino, protected (monosubstituted)amino, (disubstituted)amino, guanidino,

protected guanidino, heterocyclic ring, substituted heterocyclic ring, imidazolyl, indolyl, pyrrolidinyl, C₁ to C₁₂ alkoxy, C₁ to C₁₂ acyl, C₁ to C₁₂ acyloxy, nitro, carboxy, protected carboxy, carbamoyl, carboxamide, 5 protected carboxamide, N-(C₁ to C₁₂ alkyl)carboxamide, protected N-(C₁ to C₁₂ alkyl)carboxamide, N,N-di(C₁ to C₁₂ alkyl)carboxamide, cyano, methylsulfonylamino, thiol, C₁ to C₁₀ alkylthio or C₁ to C₁₀ alkylsulfonyl groups. The substituted alkyl groups may be substituted once or more, 10 and preferably once or twice, with the same or with different substituents.

Examples of the above substituted alkyl groups include the 2-oxo-prop-1-yl, 3-oxo-but-1-yl, cyanomethyl, nitromethyl, chloromethyl, hydroxymethyl, 15 tetrahydropyranyloxymethyl, trityloxymethyl, propionyloxymethyl, aminomethyl, carboxymethyl, allyloxycarbonylmethyl, allyloxycarbonylaminomethyl, methoxymethyl, ethoxymethyl, t-butoxymethyl, acetoxymethyl, chloromethyl, bromomethyl, iodomethyl, 20 trifluoromethyl, 6-hydroxyhexyl, 2,4-dichloro(n-butyl), 2-aminopropyl, 1-chloroethyl, 2-chloroethyl, 1-bromoethyl, 2-chloroethyl, 1-fluoroethyl, 2-fluoroethyl, 1-iodoethyl, 2-iodoethyl, 1-chloropropyl, 2-chloropropyl, 3-chloropropyl, 1-bromopropyl, 2-bromopropyl, 3-bromopropyl, 1-fluoropropyl, 2-fluoropropyl, 3-fluoropropyl, 1-iodopropyl, 2-iodopropyl, 3-iodopropyl, 2-aminoethyl, 1-aminoethyl, N-benzoyl-2-aminoethyl, N-acetyl-2-aminoethyl, N-benzoyl-1-aminoethyl, N-acetyl-1-aminoethyl and the like.

30 Examples of the above substituted alkenyl groups include styrenyl, 3-chloro-propen-1-yl, 3-chloro-buten-1-yl, 3-methoxy-propen-2-yl, 3-phenyl-buten-2-yl, 1-cyano-buten-3-yl and the like. The geometrical

isomerism is not critical, and all geometrical isomers for a given substituted alkenyl can be used.

Examples of the above substituted alkynyl groups include phenylacetylen-1-yl, 1-phenyl-2-propyn-1-yl and the like.

The term "oxo" denotes a carbon atom bonded to two additional carbon atoms substituted with an oxygen atom doubly bonded to the carbon atom, thereby forming a ketone moiety.

10 The term "protected oxo" denotes a carbon atom bonded to two additional carbon atoms substituted with two alkoxy groups or twice bonded to a substituted diol moiety, thereby forming an acyclic or cyclic ketal moiety.

15 The term " C_1 to C_{12} alkoxy" as used herein denotes groups such as methoxy, ethoxy, n-propoxy, isopropoxy, n-butoxy, t-butoxy and like groups. A preferred alkoxy is methoxy. The term " C_1 to C_{12} substituted alkoxy" means the alkyl portion of the alkoxy
20 can be substituted in the same manner as in relation to C_1 to C_{12} substituted alkyl. Similarly, the term " C_1 to C_{12} phenylalkoxy" as used herein means " C_1 to C_{12} alkoxy" bonded to a phenyl radical.

 The term " C_1 to C_{12} acyloxy" denotes herein
25 groups such as formyloxy, acetoxy, propionyloxy, butyryloxy, pivaloyloxy, pentanoyloxy, hexanoyloxy, heptanoyloxy, octanoyloxy, nonanoyloxy, decanoyloxy, undecanoyloxy, dodecanoyloxy and the like.

Similarly, the term "C₁ to C₁₂ acyl" encompasses groups such as formyl, acetyl, propionyl, butyryl, pentanoyl, pivaloyl, hexanoyl, heptanoyl, octanoyl, nonanoyl, decanoyl, undecanoyl, dodecanoyl, benzoyl and
5 the like. Preferred acyl groups are acetyl and benzoyl.

The term "C₁ to C₁₂ substituted acyl" denotes the acyl group substituted by one or more, and preferably one or two, halogen, hydroxy, protected hydroxy, oxo, protected oxo, cyclohexyl, naphthyl, amino, protected
10 amino, (monosubstituted)amino, protected (monosubstituted)amino, (disubstituted)amino, guanidino, heterocyclic ring, substituted heterocyclic ring, imidazolyl, indolyl, pyrrolidinyl, C₁ to C₁₂ alkoxy, C₁ to C₁₂ acyl, C₁ to C₁₂ acyloxy, nitro, C₁ to C₁₂ alkyl ester,
15 carboxy, protected carboxy, carbamoyl, carboxamide, protected carboxamide, N-(C₁ to C₁₂ alkyl)carboxamide, protected N-(C₁ to C₁₂ alkyl)carboxamide, N,N-di(C₁ to C₁₂ alkyl)carboxamide, cyano, methylsulfonylamino, thiol, C₁ to C₁₀ alkylthio or C₁ to C₁₀ alkylsulfonyl groups. The
20 substituted acyl groups may be substituted once or more, and preferably once or twice, with the same or with different substituents.

Examples of C₁ to C₁₂ substituted acyl groups include 4-phenylbutyroyl, 3-phenylbutyroyl,
25 3-phenylpropanoyl, 2- cyclohexanylacetyl, cyclohexanecarbonyl, 2-furanoyl and 3-dimethylaminobenzoyl.

The substituent term "C₃ to C₇ cycloalkyl" includes the cyclopropyl, cyclobutyl, cyclopentyl,
30 cyclohexyl or cycloheptyl rings. Similarly, a substituent that can be C₃ to C₇ cycloalkyl" can also be

"C₅ to C₇ cycloalkyl," which includes the cyclopentyl, cyclohexyl or cycloheptyl rings.

The substituent term "C₃ to C₇ substituted cycloalkyl" or "C₅ to C₇ substituted cycloalkyl" indicates
5 the above cycloalkyl rings substituted by one or two halogen, hydroxy, protected hydroxy, C₁ to C₁₀ alkylthio, C₁ to C₁₀ alkylsulfoxide, C₁ to C₁₀ alkylsulfonyl, C₁ to C₁₀ substituted alkylthio, C₁ to C₁₀ substituted alkylsulfoxide, C₁ to C₁₀ substituted alkylsulfonyl, C₁ to
10 C₁₂ alkyl, C₁ to C₁₂ alkoxy, C₁ to C₁₂ substituted alkyl, C₁ to C₁₂ alkoxy, oxo, protected oxo, (monosubstituted)amino, (disubstituted)amino, trifluoromethyl, carboxy, protected carboxy, phenyl, substituted phenyl, phenylthio, phenylsulfoxide, phenylsulfonyl, amino, or protected
15 amino groups.

The term "cycloalkylene" means a cycloalkyl, as defined above, where the cycloalkyl radical is bonded at two positions connecting together two separate additional groups. Similarly, the term "substituted cycloalkylene"
20 means a cycloalkylene where the cycloalkyl radical is bonded at two positions connecting together two separate additional groups and further bearing at least one additional substituent.

The term "C₅ to C₇ cycloalkenyl" indicates a
25 1,2, or 3-cyclopentenyl ring, a 1,2,3 or 4-cyclohexenyl ring or a 1,2,3,4 or 5-cycloheptenyl ring, while the term "substituted C₅ to C₇ cycloalkenyl" denotes the above C₅ to C₇ cycloalkenyl rings substituted by a C₁ to C₁₂ alkyl radical, halogen, hydroxy, protected hydroxy, C₁ to C₁₂
30 alkoxy, trifluoromethyl, carboxy, protected carboxy, oxo, protected oxo, (monosubstituted)amino, protected

(monosubstituted)amino, (disubstituted)amino, phenyl, substituted phenyl, amino, or protected amino.

The term "C₃ to C₇ cycloalkenylene" is a cycloalkenyl ring, as defined above, where the
5 cycloalkenyl radical is bonded at two positions connecting together two separate additional groups. Similarly, the term "substituted C₃ to C₇ cycloalkenylene" means a cycloalkenylene further substituted by halogen, hydroxy, protected hydroxy, C₁ to C₁₀ alkylthio, C₁ to C₁₀
10 alkylsulfoxide, C₁ to C₁₀ alkylsulfonyl, C₁ to C₁₀ substituted alkylthio, C₁ to C₁₀ substituted alkylsulfoxide, C₁ to C₁₀ substituted alkylsulfonyl, C₁ to C₁₂ alkyl, C₁ to C₁₂ alkoxy, C₁ to C₁₂ substituted alkyl, C₁ to C₁₂ alkoxy, oxo, protected oxo, (monosubstituted)amino,
15 (disubstituted)amino, trifluoromethyl, carboxy, protected carboxy, phenyl, substituted phenyl, phenylthio, phenylsulfoxide, phenylsulfonyl, amino, or protected amino group.

The term "heterocycle" or "heterocyclic ring"
20 denotes optionally substituted five-membered to eight-membered rings that have 1 to 4 heteroatoms, such as oxygen, sulfur and/or nitrogen, in particular nitrogen, either alone or in conjunction with sulfur or oxygen ring atoms. These five-membered to eight-membered rings may
25 be saturated, fully unsaturated or partially unsaturated, with fully saturated rings being preferred. Preferred heterocyclic rings include morpholino, piperidinyl, piperazinyl, 2-amino-imidazolyl, tetrahydrofurano, pyrrolo, tetrahydrothiophen-yl, hexylmethylenimine and
30 heptylmethylenimine.

The term "substituted heterocycle" or "substituted heterocyclic ring" means the above-described

heterocyclic ring is substituted with, for example, one or more, and preferably one or two, substituents which are the same or different which substituents can be halogen, hydroxy, protected hydroxy, cyano, nitro, C₁ to C₁₂ alkyl, C₁ to C₁₂ alkoxy, C₁ to C₁₂ substituted alkoxy, C₁ to C₁₂ acyl, C₁ to C₁₂ acyloxy, carboxy, protected carboxy, carboxymethyl, protected carboxymethyl, hydroxymethyl, protected hydroxymethyl, amino, protected amino, (monosubstituted)amino, protected (monosubstituted)amino, (disubstituted)amino carboxamide, protected carboxamide, N-(C₁ to C₁₂ alkyl)carboxamide, protected N-(C₁ to C₁₂ alkyl)carboxamide, N, N-di(C₁ to C₁₂ alkyl)carboxamide, trifluoromethyl, N-((C₁ to C₁₂ alkyl)sulfonyl)amino, N-(phenylsulfonyl)amino, heterocycle or substituted heterocycle groups.

The term "heteroaryl" means a heterocyclic aromatic derivative which is a five-membered or six-membered ring system having from 1 to 4 heteroatoms, such as oxygen, sulfur and/or nitrogen, in particular nitrogen, either alone or in conjunction with sulfur or oxygen ring atoms. Examples of heteroaryls include pyridinyl, pyrimidinyl, and pyrazinyl, pyridazinyl, pyrrolo, furano, oxazolo, isoxazolo, phthalimido, thiazolo and the like.

The term "substituted heteroaryl" means the above-described heteroaryl is substituted with, for example, one or more, and preferably one or two, substituents which are the same or different which substituents can be halogen, hydroxy, protected hydroxy, cyano, nitro, C₁ to C₁₂ alkyl, C₁ to C₁₂ alkoxy, C₁ to C₁₂ substituted alkoxy, C₁ to C₁₂ acyl, C₁ to C₁₂ substituted acyl, C₁ to C₁₂ acyloxy, carboxy, protected carboxy, carboxymethyl, protected carboxymethyl, hydroxymethyl,

protected hydroxymethyl, amino, protected amino,
(monosubstituted)amino, protected (monosubstituted)amino,
(disubstituted)amino, carboxamide, protected carboxamide,
N-(C₁ to C₁₂ alkyl)carboxamide, protected N-(C₁ to C₁₂
5 alkyl)carboxamide, N, N-di(C₁ to C₁₂ alkyl)carboxamide,
trifluoromethyl; N-((C₁ to C₁₂ alkyl)sulfonyl)amino or N-
(phenylsulfonyl)amino groups.

The term "C₇ to C₁₈ phenylalkyl" denotes a C₁ to
C₁₂ alkyl group substituted at any position within the
10 alkyl chain by a phenyl. The definition includes groups
of the formula: -phenyl-alkyl, -alkyl-phenyl and -alkyl-
phenyl-alkyl. Examples of such a group include benzyl,
2-phenylethyl, 3-phenyl(n-propyl), 4-phenylhexyl, 3-
phenyl(n-amyl), 3-phenyl(sec-butyl) and the like.
15 Preferred C₇ to C₁₈ phenylalkyl groups are any one of the
preferred alkyl groups described herein combined with a
phenyl group.

Similarly, the term "C₁ to C₁₂ heterocycloalkyl"
denotes a C₁ to C₁₂ alkyl group substituted at any
20 position within the alkyl chain by a "heterocycle," as
defined herein. The definition includes groups of the
formula: -heterocyclic-alkyl, -alkyl-heterocyclic and
-alkyl-heterocyclic-alkyl. Examples of such a group
include 2-pyridylethyl, 3-pierydyl(n-propyl), 4-
25 furylhexyl, 3-piperazyl(n-amyl), 3-morpholyl(sec-butyl)
and the like. Preferred C₁ to C₁₂ heterocycloalkyl groups
are any one of the preferred alkyl groups described
herein combined with any one of the preferred heterocycle
groups described herein.

30 The terms "C₇ to C₁₈ substituted phenylalkyl"
and "C₁ to C₁₂ substituted heterocycloalkyl" denote a C₇ to
C₁₈ phenylalkyl group or C₁ to C₁₂ heterocycloalkyl

substituted (on the alkyl or, where applicable, phenyl or heterocyclic portion) with one or more, and preferably one or two, groups chosen from halogen, hydroxy, protected hydroxy, oxo, protected oxo, amino, protected amino, (monosubstituted)amino, protected (monosubstituted)amino, (disubstituted)amino, guanidino, protected guanidino, heterocyclic ring, substituted heterocyclic ring, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, C₁ to C₁₂ alkoxy, C₁ to C₁₂ substituted alkoxy, C₁ to C₁₂ acyl, C₁ to C₁₂ substituted acyl, C₁ to C₁₂ acyloxy, nitro, carboxy, protected carboxy, carbamoyl, carboxamide, protected carboxamide, N-(C₁ to C₁₂ alkyl)carboxamide, protected N-(C₁ to C₁₂ alkyl)carboxamide, N, N-(C₁ to C₁₂ dialkyl)carboxamide, cyano, N-(C₁ to C₁₂ alkylsulfonyl)amino, thiol, C₁ to C₁₀ alkylthio, C₁ to C₁₀ alkylsulfonyl groups; and/or the phenyl group may be substituted with one or more, and preferably one or two, substituents chosen from halogen, hydroxy, protected hydroxy, cyano, nitro, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, C₁ to C₁₂ alkoxy, C₁ to C₁₂ substituted alkoxy, C₁ to C₁₂ acyl, C₁ to C₁₂ substituted acyl, C₁ to C₁₂ acyloxy, carboxy, protected carboxy, carboxymethyl, protected carboxymethyl, hydroxymethyl, protected hydroxymethyl, amino, protected amino, (monosubstituted)amino, protected (monosubstituted)amino, (disubstituted)amino, carboxamide, protected carboxamide, N-(C₁ to C₁₂ alkyl)carboxamide, protected N-(C₁ to C₁₂ alkyl)carboxamide, N, N-di(C₁ to C₁₂ alkyl)carboxamide, trifluoromethyl, N-((C₁ to C₁₂ alkyl)sulfonyl)amino, N-(phenylsulfonyl)amino, cyclic C₂ to C₁₂ alkylene or a phenyl group, substituted or unsubstituted, for a resulting biphenyl group. The substituted alkyl, phenyl or heterocyclic groups may be substituted with one or more, and preferably one or two, substituents which can be the same or different.

Examples of the term " C_7 to C_{18} substituted phenylalkyl" include groups such as 2-phenyl-1-chloroethyl, 2-(4-methoxyphenyl)ethyl, 4-(2,6-dihydroxyphenyl)n-hexyl, 2-(5-cyano-3-methoxyphenyl)n-pentyl, 3-(2,6-dimethylphenyl)n-propyl, 4-chloro-3-aminobenzyl, 6-(4-methoxyphenyl)-3-carboxy(n-hexyl), 5-(4-aminomethylphenyl)-3-(aminomethyl)n-pentyl, 5-phenyl-3-oxo-n-pent-1-yl and the like.

The term " C_7 to C_{18} phenylalkylene" specifies a C_7 to C_{18} phenylalkyl, as defined above, where the phenylalkyl radical is bonded at two different positions connecting together two separate additional groups. The definition includes groups of the formula: -phenyl-alkyl- and -alkyl-phenyl-alkyl-. Substitutions on the phenyl ring can be 1,2, 1,3 or 1,4.

Similarly, the term " C_1 to C_{12} heterocycloalkylene" specifies a C_1 to C_{12} heterocycloalkyl, as defined above, where the heterocycloalkyl radical is bonded at two different positions connecting together two separate additional groups. The definition includes groups of the formula: -heterocyclic-alkyl-, -alkyl-heterocyclic and -alkyl-heterocyclic-alkyl-.

The terms " C_7 to C_{18} substituted phenylalkylene" and " C_1 to C_{12} substituted heterocycloalkylene" means a C_7 to C_{18} phenylalkylene or C_1 to C_{12} heterocycloalkylene as defined above that is further substituted by halogen, hydroxy, protected hydroxy, C_1 to C_{10} alkylthio, C_1 to C_{10} alkylsulfoxide, C_1 to C_{10} alkylsulfonyl, C_1 to C_{10} substituted alkylthio, C_1 to C_{10} substituted alkylsulfoxide, C_1 to C_{10} substituted alkylsulfonyl, C_1 to C_{12} alkyl, C_1 to C_{12} alkoxy, C_1 to C_{12} substituted alkyl, C_1

to C₁₂ alkoxy, oxo, protected oxo, (monosubstituted)amino, (disubstituted)amino, trifluoromethyl, carboxy, protected carboxy, phenyl, substituted phenyl, phenylthio, phenylsulfoxide, phenylsulfonyl, amino, or protected
5 amino group on the phenyl ring or on the alkyl group.

The term "substituted phenyl" specifies a phenyl group substituted with one or more, and preferably one or two, moieties chosen from the groups consisting of halogen, hydroxy, protected hydroxy, cyano, nitro, C₁ to
10 C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, C₁ to C₁₂ alkoxy, C₁ to C₁₂ substituted alkoxy, C₁ to C₁₂ acyl, C₁ to C₁₂ substituted acyl, C₁ to C₁₂ acyloxy, carboxy, protected carboxy, carboxymethyl, protected carboxymethyl, hydroxymethyl, protected hydroxymethyl, amino, protected
15 amino, (monosubstituted)amino, protected (monosubstituted)amino, (disubstituted)amino, carboxamide, protected carboxamide, N-(C₁ to C₁₂ alkyl)carboxamide, protected N-(C₁ to C₁₂ alkyl)carboxamide, N, N-di(C₁ to C₁₂ alkyl)carboxamide,
20 trifluoromethyl, N-((C₁ to C₁₂ alkyl)sulfonyl)amino, N-(phenylsulfonyl)amino or phenyl, wherein the phenyl is substituted or unsubstituted, such that, for example, a biphenyl results.

Examples of the term "substituted phenyl"
25 includes a mono- or di(halo)phenyl group such as 2, 3 or 4-chlorophenyl, 2,6-dichlorophenyl, 2,5-dichlorophenyl, 3,4-dichlorophenyl, 2, 3 or 4-bromophenyl, 3,4-dibromophenyl, 3-chloro-4-fluorophenyl, 2, 3 or 4-fluorophenyl and the like; a mono or di(hydroxy)phenyl
30 group such as 2, 3 or 4-hydroxyphenyl, 2,4-dihydroxyphenyl, the protected-hydroxy derivatives thereof and the like; a nitrophenyl group such as 2, 3 or 4-nitrophenyl; a cyanophenyl group, for example, 2, 3 or

4-cyanophenyl; a mono- or di(alkyl)phenyl group such as 2, 3 or 4-methylphenyl, 2,4-dimethylphenyl, 2, 3 or 4-(iso-propyl)phenyl, 2, 3 or 4-ethylphenyl, 2, 3 or 4-(n-propyl)phenyl and the like; a mono or
5 di(alkoxyl)phenyl group, for example, 2,6-dimethoxyphenyl, 2, 3 or 4-methoxyphenyl, 2, 3 or 4-ethoxyphenyl, 2, 3 or 4-(isopropoxy)phenyl, 2, 3 or 4-(t-butoxy)phenyl, 3-ethoxy-4-methoxyphenyl and the like; 2, 3 or 4-trifluoromethylphenyl; a mono- or
10 dicarboxyphenyl or (protected carboxy)phenyl group such as 2, 3 or 4-carboxyphenyl or 2,4-di(protected carboxy)phenyl; a mono-or di(hydroxymethyl)phenyl or (protected hydroxymethyl)phenyl such as 2, 3, or 4-(protected hydroxymethyl)phenyl or
15 3,4-di(hydroxymethyl)phenyl; a mono- or di(aminomethyl)phenyl or (protected aminomethyl)phenyl such as 2, 3 or 4-(aminomethyl)phenyl or 2,4-(protected aminomethyl)phenyl; or a mono- or di(N-(methylsulfonylamino))phenyl such as 2, 3 or
20 4-(N-(methylsulfonylamino))phenyl. Also, the term "substituted phenyl" represents disubstituted phenyl groups wherein the substituents are different, for example, 3-methyl-4-hydroxyphenyl, 3-chloro-4-hydroxyphenyl, 2-methoxy-4-bromophenyl,
25 4-ethyl-2-hydroxyphenyl, 3-hydroxy-4-nitrophenyl, 2-hydroxy 4-chlorophenyl and the like.

The term "phenoxy" denotes a phenyl bonded to an oxygen atom, wherein the binding to the rest of the molecule is through the oxygen atom. The term
30 "substituted phenoxy" specifies a phenoxy group substituted with one or more, and preferably one or two, moieties chosen from the groups consisting of halogen, hydroxy, protected hydroxy, cyano, nitro, C₁ to C₁₂ alkyl, C₁ to C₁₂ alkoxy, C₁ to C₁₂ substituted alkoxy, C₁ to C₁₂

acyl, C₁ to C₁₂ acyloxy, carboxy, protected carboxy, carboxymethyl, protected carboxymethyl, hydroxymethyl, protected hydroxymethyl, amino, protected amino, (monosubstituted)amino, protected (monosubstituted)amino, 5 (disubstituted)amino, carboxamide, protected carboxamide, N-(C₁ to C₁₂ alkyl)carboxamide, protected N-(C₁ to C₁₂ alkyl)carboxamide, N, N-di(C₁ to C₁₂ alkyl)carboxamide, trifluoromethyl, N-((C₁ to C₁₂ alkyl)sulfonyl)amino and N-(phenylsulfonyl)amino.

- 10 Examples of substituted phenoxy include
2-methylphenoxy, 2-ethylphenoxy, 2-propylphenoxy,
2-isopropylphenoxy, 2-sec-butylphenoxy,
2-tert-butylphenoxy, 2-allylphenoxy, 2-propenylphenoxy,
2-cyclopentylphenoxy, 2-fluorophenoxy,
15 2-(trifluoromethyl)phenoxy, 2-chlorophenoxy,
2-bromophenoxy, 2-methoxyphenoxy, 2-ethoxyphenoxy,
2-isopropoxyphenoxy, 3-methylphenoxy, 3-ethylphenoxy,
3-isopropylphenoxy, 3-tert-butylphenoxy,
3-pentadecylphenoxy, 3-(trifluoromethyl)phenoxy,
20 3-fluorophenoxy, 3-chlorophenoxy, 3-bromophenoxy,
3-iodophenoxy, 3-methoxyphenoxy,
3-(trifluoromethoxy)phenoxy, 4-methylphenoxy,
4-ethylphenoxy, 4-propylphenoxy, 4-isopropylphenoxy,
4-sec-butylphenoxy, 4-tert-butylphenoxy,
25 4-tert-amylphenoxy, 4-nonylphenoxy, 4-dodecylphenoxy,
4-cyclopentylphenoxy, 4-(trifluoromethyl)phenoxy,
4-fluorophenoxy, 4-chlorophenoxy, 4-bromophenoxy,
4-iodophenoxy, 4-methoxyphenoxy,
4-(trifluoromethoxy)phenoxy, 4-ethoxyphenoxy,
30 4-propoxyphenoxy, 4-butoxyphenoxy, 4-hexyloxyphenoxy,
4-heptyloxyphenoxy, 2,3-dimethylphenoxy,
5,6,7,8-tetrahydro-1-naphthoxy, 2,3-dichlorophenoxy,
2,3-dihydro-2,2-dimethyl-7-benzofuranoxo,
2,3-dimethoxyphenoxy, 2,6-dimethylphenoxy,

2,6-diisopropylphenoxy, 2,6-di-sec-butylphenoxy, 2-tert-butyl-6-methylphenoxy, 2,6-di-tert-butylphenoxy, 2-allyl-6-methylphenoxy, 2,6-difluorophenoxy, 2,3-difluorophenoxy, 2,6-dichlorophenoxy, 2,6-dibromophenoxy, 2-fluoro-6-methoxyphenoxy, 2,6-dimethoxyphenoxy, 3,5-dimethylphenoxy, 5-isopropyl-3-methylphenoxy, 3,5-di-tert-butylphenoxy, 3,5-bis(trifluoromethyl)phenoxy, 3,5-difluorophenoxy, 3,5-dichlorophenoxy, 3,5-dimethoxyphenoxy, 3-chloro-5-methoxyphenoxy, 3,4-dimethylphenoxy, 5-indanoxy, 5,6,7,8-tetrahydro-2-naphthoxy, 4-chloro-3-methylphenoxy, 2,4-dimethylphenoxy, 2,5-dimethylphenoxy, 2-isopropyl-5-methylphenoxy, 4-isopropyl-3-methylphenoxy, 5-isopropyl-2-methylphenoxy, 2-tert-butyl-5-methylphenoxy, 2-tert-butyl-4-methylphenoxy, 2,4-di-tert-butylphenoxy, 2,4-di-tert-amylphenoxy, 4-fluoro-2-methylphenoxy, 4-fluoro-3-methylphenoxy, 2-chloro-4-methylphenoxy, 2-chloro-5-methylphenoxy, 4-chloro-2-methylphenoxy, 4-chloro-3-ethylphenoxy, 2-bromo-4-methylphenoxy, 4-iodo-2-methylphenoxy, 2-chloro-5-(trifluoromethyl)phenoxy, 2,4-difluorophenoxy, 2,5-difluorophenoxy, 3,4-difluorophenoxy, 4-chloro-2-fluorophenoxy, 3-chloro-4-fluorophenoxy, 4-chloro-3-fluorophenoxy, 2-bromo-4-fluorophenoxy, 4-bromo-2-fluorophenoxy, 2-bromo-5-fluorophenoxy, 2,4-dichlorophenoxy, 3,4-dichlorophenoxy, 2,5-dichlorophenoxy, 2-bromo-4-chlorophenoxy, 2-chloro-4-fluorophenoxy, 4-bromo-2-chlorophenoxy, 2,4-dibromophenoxy, 2-methoxy-4-methylphenoxy, 4-allyl-2-methylphenoxy, trans-2-ethoxy-5-(1-propenyl)phenoxy, 2-methoxy-4-propenylphenoxy, 3,4-dimethoxyphenoxy, 3-ethoxy-4-methoxyphenoxy, 4-allyl-2,6-dimethoxyphenoxy, 3,4-methylenedioxyphenoxy, 2,3,6-trimethylphenoxy, 2,4-dichloro-3-methylphenoxy, 2,3,4-trifluorophenoxy, 2,3,6-trifluorophenoxy, 2,3,5-trifluorophenoxy,

- 2,3,4-trichlorophenoxy, 2,3,6-trichlorophenoxy,
 2,3,5-trimethylphenoxy, 3,4,5-trimethylphenoxy, 4-chloro-
 3,5-dimethylphenoxy, 4-bromo-3,5-dimethylphenoxy,
 2,4,6-trimethylphenoxy, 2,6-bis(hydroxymethyl)-4-
 5 methylphenoxy, 2,6-di-tert-butyl-4-methylphenoxy, 2,6-
 di-tert-butyl-4-methoxyphenoxy, 2,4,5- trifluorophenoxy,
 2-chloro-3,5-difluorophenoxy, 2,4,6-trichlorophenoxy,
 3,4,5-trimethoxyphenoxy, 2,3,5-trichlorophenoxy, 4-bromo-
 2,6-dimethylphenoxy, 4-bromo-6-chloro-2-methylphenoxy,
 10 2,6-dibromo-4-methylphenoxy, 2,6-dichloro-4-
 fluorophenoxy, 2,6-dibromo-4-fluorophenoxy,
 2,4,6-tribromophenoxy, 2,4,6-triiodophenoxy, 2-chloro-
 4,5-dimethylphenoxy, 4-chloro-2-isopropyl-5-
 methylphenoxy, 2-bromo-4,5-difluorophenoxy,
 15 2,4,5-trichlorophenoxy, 2,3,5,6-tetrafluorophenoxy and
 the like.

The term "C₇ to C₁₈ substituted phenylalkoxy" denotes a C₇ to C₁₈ phenylalkoxy group bonded to the rest of the molecule through the oxygen atom, wherein the
 20 phenylalkyl portion is substituted with one or more, and preferably one or two, groups selected from halogen, hydroxy, protected hydroxy, oxo, protected oxo, amino, protected amino, (monosubstituted)amino, protected (monosubstituted)amino, (disubstituted)amino, guanidino,
 25 heterocyclic ring, substituted heterocyclic ring, C₁ to C₁₂ alkoxy, C₁ to C₁₂ acyl, C₁ to C₁₂ acyloxy, nitro, carboxy, protected carboxy, carbamoyl, carboxamide, protected carboxamide, N-(C₁ to C₁₂ alkyl)carboxamide, protected N-(C₁ to C₁₂ alkyl)carboxamide, N, N-(C₁ to C₁₂
 30 dialkyl)carboxamide, cyano, N-(C₁ to C₁₂ alkylsulfonyl)amino, thiol, C₁ to C₁₀ alkylthio, C₁ to C₁₀ alkylsulfonyl groups; and/or the phenyl group can be substituted with one or more, and preferably one or two, substituents chosen from halogen, hydroxy, protected

hydroxy, cyano, nitro, C₁ to C₁₂ alkyl, C₁ to C₁₂ alkoxy, C₁ to C₁₂ acyl, C₁ to C₁₂ acyloxy, carboxy, protected carboxy, carboxymethyl, protected carboxymethyl, hydroxymethyl, protected hydroxymethyl, amino, protected
5 amino, (monosubstituted)amino, protected (monosubstituted)amino, (disubstituted)amino, carboxamide, protected carboxamide, N-(C₁ to C₁₂ alkyl) carboxamide, protected N-(C₁ to C₁₂ alkyl) carboxamide, N, N-di(C₁ to C₁₂ alkyl)carboxamide, trifluoromethyl,
10 N-((C₁ to C₁₂ alkyl)sulfonyl)amino, N-(phenylsulfonyl)amino or a phenyl group, substituted or unsubstituted, for a resulting biphenyl group. The substituted alkyl or phenyl groups may be substituted with one or more, and preferably one or two, substituents
15 which can be the same or different.

Examples of the term "C₁ to C₁₈ substituted phenylalkoxy" include groups such as 2-(4-hydroxyphenyl)ethoxy, 4-(4-methoxyphenyl)butoxy, (2R)-3-phenyl-2-amino-propoxy, (2S)-3-phenyl-2-amino-propoxy,
20 2-indanoxo, 6-phenyl-1-hexanoxo, cinnamyloxy, (+/-)-2-phenyl-1-propoxy, 2,2-dimethyl-3-phenyl-1-propoxy and the like.

The term "phthalimide" means a cyclic imide which is made from phthalic acid, also called
25 1,2-benzenedicarboxylic acid. The term "substituted phthalimide" specifies a phthalimide group substituted with one or more, and preferably one or two, moieties chosen from the groups consisting of halogen, hydroxy, protected hydroxy, cyano, nitro, C₁ to C₁₂ alkyl, C₁ to C₁₂
30 alkoxy, C₁ to C₁₂ substituted alkoxy, C₁ to C₁₂ acyl, C₁ to C₁₂ acyloxy, carboxy, protected carboxy, carboxymethyl, protected carboxymethyl, hydroxymethyl, protected hydroxymethyl, amino, protected amino,

(monosubstituted)amino, protected (monosubstituted)amino, (disubstituted)amino, carboxamide, protected carboxamide, N-(C₁ to C₁₂ alkyl)carboxamide, protected N-(C₁ to C₁₂ alkyl)carboxamide, N, N-di(C₁ to C₁₂ alkyl)carboxamide, trifluoromethyl, N-((C₁ to C₁₂ alkyl)sulfonyl)amino and N-(phenylsulfonyl)amino.

Examples of substituted phthalimides include 4,5-dichlorophthalimido, 3-fluorophthalimido, 4-methoxyphthalimido, 3-methylphthalimido, 4-carboxyphthalimido and the like.

The term "substituted naphthyl" specifies a naphthyl group substituted with one or more, and preferably one or two, moieties either on the same ring or on different rings chosen from the groups consisting of halogen, hydroxy, protected hydroxy, cyano, nitro, C₁ to C₆ alkyl, C₁ to C₇ alkoxy, C₁ to C₇ acyl, C₁ to C₇ acyloxy, carboxy, protected carboxy, carboxymethyl, protected carboxymethyl, hydroxymethyl, protected hydroxymethyl, amino, protected amino, (monosubstituted)amino, protected (monosubstituted)amino, (disubstituted)amino, carboxamide, protected carboxamide, N-(C₁ to C₁₂ alkyl)carboxamide, protected N-(C₁ to C₁₂ alkyl)carboxamide, N, N-di(C₁ to C₁₂ alkyl)carboxamide, trifluoromethyl, N-((C₁ to C₁₂ alkyl)sulfonyl)amino or N-(phenylsulfonyl)amino.

Examples of the term "substituted naphthyl" includes a mono or di(halo)naphthyl group such as 1, 2, 3, 4, 5, 6, 7 or 8-chloronaphthyl, 2, 6-dichloronaphthyl, 2, 5-dichloronaphthyl, 3, 4-dichloronaphthyl, 1, 2, 3, 4, 5, 6, 7 or 8-bromonaphthyl, 3, 4-dibromonaphthyl, 3-chloro-4-fluoronaphthyl, 1, 2, 3, 4, 5, 6, 7 or 8-fluoronaphthyl and the like; a mono or

di(hydroxy)naphthyl group such as 1, 2, 3, 4, 5, 6, 7 or 8-hydroxynaphthyl, 2, 4-dihydroxynaphthyl, the protected-hydroxy derivatives thereof and the like; a nitronaphthyl group such as 3- or 4-nitronaphthyl; a cyanonaphthyl group, for example, 1, 2, 3, 4, 5, 6, 7 or 8-cyanonaphthyl; a mono- or di(alkyl)naphthyl group such as 2, 3, 4, 5, 6, 7 or 8-methylnaphthyl, 1, 2, 4-dimethylnaphthyl, 1, 2, 3, 4, 5, 6, 7 or 8-(isopropyl)naphthyl, 1, 2, 3, 4, 5, 6, 7 or 8-ethylnaphthyl, 1, 2, 3, 4, 5, 6, 7 or 8-(n-propyl)naphthyl and the like; a mono or di(alkoxy)naphthyl group, for example, 2, 6-dimethoxynaphthyl, 1, 2, 3, 4, 5, 6, 7 or 8-methoxynaphthyl, 1, 2, 3, 4, 5, 6, 7 or 8-ethoxynaphthyl, 1, 2, 3, 4, 5, 6, 7 or 8-(isopropoxy)naphthyl, 1, 2, 3, 4, 5, 6, 7 or 8-(t-butoxy)naphthyl, 3-ethoxy-4-methoxynaphthyl and the like; 1, 2, 3, 4, 5, 6, 7 or 8-trifluoromethylnaphthyl; a mono- or dicarboxynaphthyl or (protected carboxy)naphthyl group such as 1, 2, 3, 4, 5, 6, 7 or 8-carboxynaphthyl or 2, 4-di(-protected carboxy)naphthyl; a mono-or di(hydroxymethyl)naphthyl or (protected hydroxymethyl)naphthyl such as 1, 2, 3, 4, 5, 6, 7 or 8-(protected hydroxymethyl)naphthyl or 3, 4-di(hydroxymethyl)naphthyl; a mono- or di(amino)naphthyl or (protected amino)naphthyl such as 1, 2, 3, 4, 5, 6, 7 or 8-(amino)naphthyl or 2, 4-(protected amino)-naphthyl, a mono- or di(aminomethyl)naphthyl or (protected aminomethyl)naphthyl such as 2, 3, or 4-(aminomethyl)naphthyl or 2, 4-(protected aminomethyl)-naphthyl; or a mono- or di-(N-methylsulfonylamino)naphthyl such as 1, 2, 3, 4, 5, 6, 7 or 8-(N-methylsulfonylamino)naphthyl. Also, the term "substituted naphthyl" represents disubstituted naphthyl groups wherein the substituents are different, for

example, 3-methyl-4-hydroxynaphth-1-yl, 3-chloro-4-hydroxynaphth-2-yl, 2-methoxy-4-bromonaphth-1-yl, 4-ethyl-2-hydroxynaphth-1-yl, 3-hydroxy-4-nitronaphth-2-yl, 2-hydroxy-4-chloronaphth-1-yl, 2-methoxy-7-bromonaphth-1-yl, 4-ethyl-5-hydroxynaphth-2-yl, 3-hydroxy-8-nitronaphth-2-yl, 2-hydroxy-5-chloronaphth-1-yl and the like.

The term "naphthylene" means a naphthyl radical bonded at two positions connecting together two separate additional groups. Similarly, the term "substituted naphthylene" means a naphthylene group that is further substituted by halogen, hydroxy, protected hydroxy, C₁ to C₁₀ alkylthio, C₁ to C₁₀ alkylsulfoxide, C₁ to C₁₀ alkylsulfonyl, C₁ to C₁₀ substituted alkylthio, C₁ to C₁₀ substituted alkylsulfoxide, C₁ to C₁₀ substituted alkylsulfonyl, C₁ to C₁₂ alkyl, C₁ to C₁₂ alkoxy, C₁ to C₁₂ substituted alkyl, C₁ to C₁₂ alkoxy, oxo, protected oxo, (monosubstituted)amino, (disubstituted)amino, trifluoromethyl, carboxy, protected carboxy, phenyl, substituted phenyl, phenylthio, phenylsulfoxide, phenylsulfonyl, amino, or protected amino group.

The terms "halo" and "halogen" refer to the fluoro, chloro, bromo or iodo atoms. There can be one or more halogens, which are the same or different.

Preferred halogens are chloro and fluoro.

The term "(monosubstituted)amino" refers to an amino group with one substituent chosen from the group consisting of phenyl, substituted phenyl, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, C₁ to C₁₂ acyl, C₁ to C₁₂ substituted acyl, C₂ to C₁₂ alkenyl, C₂ to C₁₂ substituted alkenyl, C₂ to C₁₂ alkynyl, C₂ to C₁₂ substituted alkynyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈ substituted phenylalkyl,

heterocyclic ring, substituted heterocyclic ring, C₁ to C₁₂ heterocycloalkyl and C₁ to C₁₂ substituted heterocycloalkyl. The (monosubstituted)amino can additionally have an amino-protecting group as
5 encompassed by the term "protected (monosubstituted)amino."

The term "(disubstituted)amino" refers to an amino group with two substituents chosen from the group consisting of phenyl, substituted phenyl, C₁ to C₁₂ alkyl,
10 C₁ to C₁₂ substituted alkyl, C₁ to C₁₂ acyl, C₂ to C₁₂ alkenyl, C₂ to C₁₂ alkynyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈ substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl and C₁ to C₁₂ substituted heterocycloalkyl,. The two substituents can be the same or different.

15 The term "amino-protecting group" as used herein refers to substituents of the amino group commonly employed to block or protect the amino functionality while reacting other functional groups of the molecule. The term "protected (monosubstituted)amino" means there
20 is an amino-protecting group on the monosubstituted amino nitrogen atom. In addition, the term "protected carboxamide" means there is an amino-protecting group on the carboxamide nitrogen. Similarly, the term "protected N-(C₁ to C₁₂ alkyl)carboxamide" means there is an amino-
25 protecting group on the carboxamide nitrogen.

Examples of such amino-protecting groups include the formyl ("For") group, the trityl group, the phthalimido group, the trichloroacetyl group, the chloroacetyl, bromoacetyl, and iodoacetyl groups,
30 urethane-type blocking groups, such as t-butoxycarbonyl ("Boc"), 2-(4-biphenyl)propyl-2-oxycarbonyl ("Bpoc"), 2-phenylpropyl-2-oxycarbonyl ("Poc"),

2-(4-xenyl)isopropoxycarbonyl, 1,1-diphenylethyl-1-oxycarbonyl, 1,1-diphenylpropyl-1-oxycarbonyl, 2-(3,5-dimethoxyphenyl)propyl-2-oxycarbonyl ("Ddz"), 2-(p-toluy)l)propyl-2-oxycarbonyl, cyclopentanyloxycarbonyl, 5 1-methylcyclopentanyloxycarbonyl, cyclohexanyloxy-carbonyl, 1-methylcyclohexanyloxycarbonyl, 2-methylcyclohexanyloxycarbonyl, 2-(4-toluy)lsulfonyl)-ethoxycarbonyl, 2-(methylsulfonyl)ethoxycarbonyl, 2-(triphenylphosphino)-ethoxycarbonyl, 10 9-fluorenylmethoxycarbonyl ("Fmoc"), 2-(trimethylsilyl)ethoxycarbonyl, allyloxycarbonyl, 1-(trimethylsilylmethyl)prop-1-enyloxycarbonyl, 5-benzisoxalylmethoxycarbonyl, 4-acetoxybenzyl-oxycarbonyl, 2,2,2-trichloroethoxycarbonyl, 2-ethynyl-2-15 propoxycarbonyl, cyclopropylmethoxycarbonyl, isobornyloxycarbonyl, 1-piperidyloxycarbonyl, benzyloxycarbonyl ("Cbz"), 4-phenylbenzyloxycarbonyl, 2-methylbenzyloxy-carbonyl, -2,4,5,- tetramethylbenzyloxycarbonyl ("Tmz"), 20 4-methoxybenzyloxycarbonyl, 4-fluorobenzyloxycarbonyl, 4-chlorobenzyloxycarbonyl, 3-chlorobenzyloxycarbonyl, 2-chlorobenzyloxycarbonyl, 2,4-dichlorobenzyl-oxycarbonyl, 4-bromobenzyloxycarbonyl, 3-bromobenzyloxycarbonyl, 4-nitrobenzyloxy-carbonyl, 25 4-cyanobenzyloxycarbonyl, 4-(decyloxy)benzyloxycarbonyl and the like; the benzoylmethylsulfonyl group, dithiasuccinoyl ("Dts"), the 2-(nitro)phenylsulfenyl group ("Nps"), the diphenyl-phosphine oxide group and like amino-protecting groups. The species of amino-30 protecting group employed is not critical so long as the derivatized amino group is stable to the conditions of the subsequent reaction(s) and can be removed at the appropriate point without disrupting the remainder of the compounds. Preferred amino-protecting groups are Boc, 35 Cbz and Fmoc. Further examples of amino-protecting

groups embraced by the above term are well known in organic synthesis and the peptide art and are described by, for example, T.W. Greene and P.G.M. Wuts, "Protective Groups in Organic Synthesis," 2nd ed., John Wiley and Sons, New York, NY, 1991, Chapter 7, M. Bodanzsky, "Principles of Peptide Synthesis," 1st and 2nd revised ed., Springer-Verlag, New York, NY, 1984 and 1993, and Stewart and Young, "Solid Phase Peptide Synthesis," 2nd ed., Pierce Chemical Co., Rockford, IL, 1984, each of which is incorporated herein by reference. The related term "protected amino" defines an amino group substituted with an amino-protecting group discussed above.

The term "protected guanidino" as used herein refers to an "amino-protecting group" on one or two of the guanidino nitrogen atoms. Examples of "protected guanidino" groups are described by T.W. Greene and P.G.M. Wuts; M. Bodanzsky; and Stewart and Young, *supra*.

The term "carboxy-protecting group" as used herein refers to one of the ester derivatives of the carboxylic acid group commonly employed to block or protect the carboxylic acid group while reactions are carried out on other functional groups on the compound. Examples of such carboxylic acid protecting groups include t-butyl, 4-nitrobenzyl, 4-methoxybenzyl, 3,4-dimethoxybenzyl, 2,4-dimethoxybenzyl, 2,4,6-trimethoxybenzyl, 2,4,6-trimethylbenzyl, pentamethylbenzyl, 3,4-methylenedioxybenzyl, benzhydryl, 4,4'-dimethoxytrityl, 4,4',4"-trimethoxytrityl, 2-phenylpropyl, trimethylsilyl, t-butyl dimethylsilyl, phenacyl, 2,2,2-trichloroethyl, -(trimethylsilyl)ethyl, -(di(n-butyl)methylsilyl)ethyl, p-toluenesulfonyl ethyl, 4-nitrobenzylsulfonyl ethyl, allyl, cinnamyl, 1-(trimethylsilylmethyl)-propenyl and like moieties. The

species of carboxy-protecting group employed is not critical so long as the derivatized carboxylic acid is stable to the conditions of subsequent reaction(s) and can be removed at the appropriate point without
5 disrupting the remainder of the molecule. Further examples of these groups are found in E. Haslam, "Protective Groups in Organic Chemistry," J.G.W. McOmie, Ed., Plenum Press, New York, NY, 1973, Chapter 5, and T.W. Greene and P.G.M. Wuts, "Protective Groups in
10 Organic Synthesis," 2nd ed., John Wiley and Sons, New York, NY, 1991, Chapter 5, each of which is incorporated herein by reference. A related term is "protected carboxy," which refers to a carboxy group substituted with one of the above carboxy-protecting groups.

15 The term "hydroxy-protecting group" refers to readily cleavable groups bonded to hydroxyl groups, such as the tetrahydropyranyl, 2-methoxypropyl, 1-ethoxyethyl, methoxymethyl, 2-methoxyethoxymethyl, methylthiomethyl, t-butyl, t-amyl, trityl, 4-methoxytrityl,
20 4,4'-dimethoxytrityl, 4,4',4"-trimethoxytrityl, benzyl, allyl, trimethylsilyl, (t-butyl)dimethylsilyl, 2,2,2-trichloroethoxycarbonyl groups and the like. The species of hydroxy-protecting groups is not critical so long as the derivatized hydroxyl group is stable to the
25 conditions of subsequent reaction(s) and can be removed at the appropriate point without disrupting the remainder of the molecule. Further examples of hydroxy-protecting groups are described by C.B. Reese and E. Haslam, "Protective Groups in Organic Chemistry," J.G.W. McOmie,
30 Ed., Plenum Press, New York, NY, 1973, Chapters 3 and 4, respectively, and T.W. Greene and P.G.M. Wuts, "Protective Groups in Organic Synthesis," 2nd ed., John Wiley and Sons, New York, NY, 1991, Chapters 2 and 3. Related terms are "protected hydroxy," and "protected

hydroxymethyl" which refer to a hydroxy or hydroxymethyl substituted with one of the above hydroxy-protecting groups.

The term "C₁ to C₁₀ alkylthio" refers to sulfide groups such as methylthio, ethylthio, n-propylthio, isopropylthio, n-butylthio, t-butylthio and like groups. The term "C₁ to C₁₀ alkylsulfoxide" indicates sulfoxide groups such as methylsulfoxide, ethylsulfoxide, n-propylsulfoxide, isopropylsulfoxide, n-butylsulfoxide, sec-butylsulfoxide and the like. The term "C₁ to C₁₀ alkylsulfonyl" encompasses groups such as methylsulfonyl, ethylsulfonyl, n-propylsulfonyl, isopropylsulfonyl, n-butylsulfonyl, t-butylsulfonyl and the like. it should also be understood that the above thio, sulfoxide or sulfonyl groups can be at any point on the alkyl chain (e.g., 2-methylmercaptoethyl).

The terms "C₁ to C₁₀ substituted alkylthio," "C₁ to C₁₀ substituted alkylsulfoxide," and "C₁ to C₁₀ substituted alkylsulfonyl," denote the C₁ to C₁₀ alkyl portion of these groups may be substituted as described above in relation to "substituted alkyl."

The terms "phenylthio," "phenylsulfoxide," and "phenylsulfonyl" specify a thiol, a sulfoxide, or sulfone, respectively, containing a phenyl group. The terms "substituted phenylthio," "substituted phenylsulfoxide," and "substituted phenylsulfonyl" means that the phenyl of these groups can be substituted as described above in relation to "substituted phenyl."

The term "C₁ to C₁₂ alkylaminocarbonyl" means a C₁ to C₁₂ alkyl attached to a nitrogen of the aminocarbonyl group. Examples of C₁ to C₁₂

alkylaminocarbonyl include methylaminocarbonyl, ethylaminocarbonyl, propylaminocarbonyl and butylaminocarbonyl. The term " C_1 to C_{12} substituted alkylaminocarbonyl" denotes a substituted alkyl bonded to
5 a nitrogen of the aminocarbonyl group, which alkyl may be substituted as described above in relation to C_1 to C_{12} substituted alkyl. Examples of C_1 to C_{12} substituted alkylaminocarbonyl include, for example, methoxymethylaminocarbonyl, 2-chloroethylaminocarbonyl,
10 2-oxopropylaminocarbonyl and 4-phenylbutylaminocarbonyl.

The term " C_1 to C_{12} alkoxy carbonyl" means a " C_1 to C_{12} alkoxy" group attached to a carbonyl group. The term " C_1 to C_{12} substituted alkoxy carbonyl" denotes a substituted alkoxy bonded to the carbonyl group, which
15 alkoxy may be substituted as described above in relation to " C_1 to C_{12} substituted alkyl."

The term "phenylaminocarbonyl" means a phenyl attached to a nitrogen of the aminocarbonyl group. The
20 term "substituted phenylaminocarbonyl" denotes a substituted phenyl bonded to a nitrogen of the aminocarbonyl group, which phenyl may be substituted as described above in relation to substituted phenyl. Examples of substituted phenylaminocarbonyl include
25 2-chlorophenylaminocarbonyl, 3-chlorophenylaminocarbonyl, 2-nitrophenylaminocarbonyl, 4-biphenylaminocarbonyl, and 4-methoxyphenylaminocarbonyl.

The term " C_1 to C_{12} alkylaminothiocarbonyl" means a C_1 to C_{12} alkyl attached to an aminothiocarbonyl
30 group, wherein the alkyl has the same meaning as defined above. Examples of C_1 to C_{12} alkylaminothiocarbonyl include methylaminothiocarbonyl, ethylaminothiocarbonyl, propylaminothiocarbonyl and butylaminothiocarbonyl.

The term "C₁ to C₁₂ substituted alkylaminothiocarbonyl" denotes a substituted alkyl bonded to an aminothiocarbonyl group, wherein the alkyl may be substituted as described above in relation to C₁ to C₁₂ substituted alkyl. Examples of C₁ to C₁₂ substituted alkylaminothiocarbonyl include, for example, methoxymethylaminothiocarbonyl, 2-chloroethylaminothiocarbonyl, 2-oxopropylaminothiocarbonyl and 4-phenylbutylaminothiocarbonyl.

The term "phenylaminothiocarbonyl" means a phenyl attached to an aminothiocarbonyl group, wherein the phenyl has the same meaning as defined above.

The term "substituted phenylaminothiocarbonyl" denotes a substituted phenyl bonded to an aminothiocarbonyl group, wherein phenyl may be substituted as described above in relation to substituted phenyl. Examples of substituted phenylaminothiocarbonyls include 2-chlorophenylaminothiocarbonyl, 3-chlorophenylaminothiocarbonyl, 2-nitrophenylaminothiocarbonyl, 4-biphenylaminothiocarbonyl and 4-methoxyphenylaminothiocarbonyl.

The term "phenylene" means a phenyl group where the phenyl radical is bonded at two positions connecting together two separate additional groups. Examples of "phenylene" include 1,2-phenylene, 1,3-phenylene, and 1,4-phenylene.

The term "substituted phenylene" means a phenyl group where the phenyl radical is bonded at two positions connecting together two separate additional groups,

wherein the phenyl is substituted as described above in relation to "substituted phenyl."

The term "substituted C_1 to C_{12} alkylene" means
5 a C_1 to C_{12} alkyl group where the alkyl radical is bonded at two positions connecting together two separate additional groups and further bearing an additional substituent. Examples of "substituted C_1 to C_{12} alkylene" includes aminomethylene, 1-(amino)-1,2-ethyl, 2-(amino)-
10 1,2-ethyl, 1-(acetamido)-1,2-ethyl, 2-(acetamido)-1,2-ethyl, 2-hydroxy-1,1-ethyl, 1-(amino)-1,3-propyl.

The terms "cyclic C_2 to C_7 alkylene," "substituted cyclic C_2 to C_7 alkylene," "cyclic C_2 to C_7 heteroalkylene," and "substituted cyclic C_2 to C_7
15 heteroalkylene," defines such a cyclic group bonded ("fused") to the phenyl radical resulting in a bicyclic ring system. The cyclic group may be saturated or contain one or two double bonds. Furthermore, the cyclic group may have one or two methylene or methine groups
20 replaced by one or two oxygen, nitrogen or sulfur atoms which are the cyclic C_2 to C_7 heteroalkylene.

The cyclic alkylene or heteroalkylene group may be substituted once or twice by the same or different substituents which, if appropriate, can be connected to
25 another part of the compound (e.g., alkylene) selected from the group consisting of the following moieties: hydroxy, protected hydroxy, carboxy, protected carboxy, oxo, protected oxo, C_1 to C_4 acyloxy, formyl, C_1 to C_{12} acyl, C_1 to C_{12} alkyl, C_1 to C_7 alkoxy, C_1 to C_{10} alkylthio,
30 C_1 to C_{10} alkylsulfoxide, C_1 to C_{10} alkylsulfonyl, halo, amino, protected amino, (monosubstituted)amino, protected (monosubstituted)amino, (disubstituted)amino, hydroxymethyl or a protected hydroxymethyl.

The cyclic alkylene or heteroalkylene group fused onto the benzene radical can contain two to ten ring members, but it preferably contains three to six members. Examples of such saturated cyclic groups are

5 when the resultant bicyclic ring system is 2,3-dihydro-indanyl and a tetralin ring. When the cyclic groups are unsaturated, examples occur when the resultant bicyclic ring system is a naphthyl ring or indolyl. Examples of fused cyclic groups which each contain one nitrogen atom

10 and one or more double bond, preferably one or two double bonds, are when the benzene radical is fused to a pyridino, pyrano, pyrrolo, pyridinyl, dihydropyrrolo, or dihydropyridinyl ring. Examples of fused cyclic groups which each contain one oxygen atom and one or two double

15 bonds are when the benzene radical ring is fused to a furo, pyrano, dihydrofurano, or dihydropyrano ring. Examples of fused cyclic groups which each have one sulfur atom and contain one or two double bonds are when the benzene radical is fused to a thieno, thiopyrano,

20 dihydrothieno or dihydrothiopyrano ring. Examples of cyclic groups which contain two heteroatoms selected from sulfur and nitrogen and one or two double bonds are when the benzene radical ring is fused to a thiazolo, isothiazolo, dihydrothiazolo or dihydroisothiazolo ring.

25 Examples of cyclic groups which contain two heteroatoms selected from oxygen and nitrogen and one or two double bonds are when the benzene ring is fused to an oxazolo, isoxazolo, dihydrooxazolo or dihydroisoxazolo ring. Examples of cyclic groups which contain two nitrogen

30 heteroatoms and one or two double bonds occur when the benzene ring is fused to a pyrazolo, imidazolo, dihydropyrazolo or dihydroimidazolo ring or pyrazinyl.

The term "carbamoyl" means an -NCO- group where the radical is bonded at two positions connecting two separate additional groups.

One or more of the compounds of the invention,
5 even within a given library, may be present as a salt. The term "salt" encompasses those salts that form with the carboxylate anions and amine nitrogens and include salts formed with the organic and inorganic anions and cations discussed below. Furthermore, the term includes
10 salts that form by standard acid-base reactions with basic groups (such as amino groups) and organic or inorganic acids. Such acids include hydrochloric, hydrofluoric, trifluoroacetic, sulfuric, phosphoric, acetic, succinic, citric, lactic, maleic, fumaric,
15 palmitic, cholic, pamoic, mucic, D-glutamic, D-camphoric, glutaric, phthalic, tartaric, lauric, stearic, salicyclic, methanesulfonic, benzenesulfonic, sorbic, picric, benzoic, cinnamic, and like acids.

The term "organic or inorganic cation" refers
20 to counter-ions for the carboxylate anion of a carboxylate salt. The counter-ions are chosen from the alkali and alkaline earth metals, (such as lithium, sodium, potassium, barium, aluminum and calcium); ammonium and mono-, di- and tri-alkyl amines such as
25 trimethylamine, cyclohexylamine; and the organic cations, such as dibenzylammonium, benzylammonium, 2-hydroxyethylammonium, bis(2-hydroxyethyl)ammonium, phenylethylbenzylammonium, dibenzylethylenediammonium, and like cations. See, for example, "Pharmaceutical
30 Salts," Berge et al., J. Pharm. Sci., 66:1-19 (1977), which is incorporated herein by reference. Other cations encompassed by the above term include the protonated form of procaine, quinine and N-methylglucosamine, and the

protonated forms of basic amino acids such as glycine, ornithine, histidine, phenylglycine, lysine and arginine. Furthermore, any zwitterionic form of the instant compounds formed by a carboxylic acid and an amino group is referred to by this term. For example, a cation for a carboxylate anion will exist when a position is substituted with a (quaternary ammonium)methyl group. A preferred cation for the carboxylate anion is the sodium cation.

10 The compounds of the invention can also exist as solvates and hydrates. Thus, these compounds may crystallize with, for example, waters of hydration, or one, a number of, or any fraction thereof of molecules of the mother liquor solvent. The solvates and hydrates of
15 such compounds are included within the scope of this invention.

One or more compounds of the invention, even when in a library, can be in the biologically active ester form, such as the non-toxic, metabolically-labile ester-form. Such ester forms induce increased blood
20 levels and prolong the efficacy of the corresponding non-esterified forms of the compounds. Ester groups which can be used include the lower alkoxymethyl groups, for example, methoxymethyl, ethoxymethyl, isopropoxymethyl and the like; the $-(C_1 \text{ to } C_{12})$ alkoxyethyl groups, for
25 example methoxyethyl, ethoxyethyl, propoxyethyl, isopropoxyethyl and the like; the 2-oxo-1,3-dioxolen-4-ylmethyl groups, such as 5-methyl-2-oxo-1,3-dioxolen-4-ylmethyl, 5-phenyl-2-oxo-1,3-dioxolen-4-ylmethyl and the
30 like; the C_1 to C_{10} alkylthiomethyl groups, for example methylthiomethyl, ethylthiomethyl, iso-propylthiomethyl and the like; the acyloxymethyl groups, for example pivaloyloxymethyl, pivaloyloxyethyl, -acetoxymethyl and

the like; the ethoxycarbonyl-1-methyl group; the
-acetoxyethyl; the 1-(C₁ to C₁₂ alkyloxycarbonyloxy)ethyl
groups such as the 1-(ethoxycarbonyloxy)ethyl group; and
the 1-(C₁ to C₁₂ alkylaminocarbonyloxy)ethyl groups such
5 as the 1-(methyllaminocarbonyloxy)ethyl group.

The term "amino acid" includes any one of the
twenty naturally-occurring amino acids or the D-form of
any one of the naturally-occurring amino acids. In
addition, the term "amino acid" also includes other non-
10 naturally occurring amino acids besides the D-amino
acids, which are functional equivalents of the naturally-
occurring amino acids. Such non-naturally-occurring
amino acids include, for example, norleucine ("Nle"),
norvaline ("Nva"), L- or D- naphthalanine, ornithine
15 ("Orn"), homoarginine (homoArg) and others well known in
the peptide art, such as those described in M. Bodanzsky,
"Principles of Peptide Synthesis," 1st and 2nd revised
ed., Springer-Verlag, New York, NY, 1984 and 1993, and
Stewart and Young, "Solid Phase Peptide Synthesis," 2nd
20 ed., Pierce Chemical Co., Rockford, IL, 1984, both of
which are incorporated herein by reference. Amino acids
and amino acid analogs can be purchased commercially
(Sigma Chemical Co.; Advanced Chemtech) or synthesized
using methods known in the art.

25 The term "functionalized resin" means any
resin, crosslinked or otherwise, where functional groups
have been introduced into the resin, as is common in the
art. Such resins include, for example, those
functionalized with amino, alkylhalo, formyl or hydroxy
30 groups. Such resins which can serve as solid supports
are well known in the art and include, for example,
4-methylbenzhydrylamine-copoly(styrene-1% divinylbenzene)
(MBHA), 4-hydroxymethylphenoxymethyl-copoly(styrene-1%

divinylbenzene), 4-oxymethyl-phenyl-acetamido-copoly(styrene-1% divinylbenzene) (Wang), 4-(oxymethyl)-phenylacetamido methyl (Pam), and Tentagel™, from Rapp Polymere GmbH, trialkoxy-diphenyl-methyl ester-copoly(styrene-1% divinylbenzene) (RINK) all of which are commercially available. Other functionalized resins are known in the art and can be used without departure from the scope of the current invention. Such resins may include those described in Jung, G., Combinatorial Peptide and Nonpeptide Libraries, A Handbook (VCH Verlag, 1996) or Bunin, B. A., The Combinatorial Index (Academic Press, 1998) and are incorporated herein by reference.

As used herein, a "combinatorial library" is an intentionally created collection of differing molecules which can be prepared by the means provided below or otherwise and screened for biological activity in a variety of formats (e.g., libraries of soluble molecules, libraries of compounds attached to resin beads, silica chips or other solid supports). A "combinatorial library," as defined above, involves successive rounds of chemical syntheses based on a common starting structure. The combinatorial libraries can be screened in any variety of assays, such as those detailed below as well as others useful for assessing their biological activity. The combinatorial libraries will generally have at least one active compound and are generally prepared such that the compounds are in equimolar quantities.

Compounds disclosed in previous work that are not disclosed as part of a collection of compounds or not disclosed as intended for use as part of such a collection are not part of a "combinatorial library" of the invention. In addition, compounds that are in an

unintentional or undesired mixture are not part of a "combinatorial library" of the invention.

A combinatorial library of the invention can contain two or more of the above-described compounds.

5 The invention further provides a combinatorial library containing three, four or five or more of the above-described compounds. In another embodiment of the invention, a combinatorial library can contain ten or more of the above-described compounds. In yet another

10 embodiment of the invention, a combinatorial library can contain fifty or more of the above-described compounds. If desired, a combinatorial library of the invention can contain 100,000 or more, or even 1,000,000 or more, of the above-described compounds.

15 By way of example, the preparation of the combinatorial libraries can use the "split resin approach." The split resin approach is described by, for example, U.S. Patent 5,010,175 to Rutter, WO PCT 91/19735 to Simon, and Gallop et al., *J. Med. Chem.*, 37:1233-1251

20 (1994), all of which are incorporated herein by reference.

The amino acids are indicated herein by either their full name or by the commonly known three letter code. Further, in the naming of amino acids, "D-"

25 designates an amino acid having the "D" configuration, as opposed to the naturally occurring L-amino acids. Where no specific configuration is indicated, one skilled in the art would understand the amino acid to be an L-amino acid. The amino acids can, however, also be in racemic

30 mixtures of the D- and L-configuration or the D-amino acid can readily be substituted for that in the L-configuration.

For preparing pharmaceutical compositions containing compounds of the invention, inert, pharmaceutically acceptable carriers are used. The pharmaceutical carrier can be either solid or liquid.

5 Solid form preparations include, for example, powders, tablets, dispersible granules, capsules, cachets, and suppositories.

A solid carrier can be one or more substances which can also act as diluents, flavoring agents,

10 solubilizers, lubricants, suspending agents, binders, or tablet disintegrating agents; it can also be an encapsulating material.

In powders, the carrier is generally a finely divided solid which is in a mixture with the finely

15 divided active component. In tablets, the active compound is mixed with the carrier having the necessary binding properties in suitable proportions and compacted in the shape and size desired.

For preparing pharmaceutical composition in the

20 form of suppositories, a low-melting wax such as a mixture of fatty acid glycerides and cocoa butter is first melted and the active ingredient is dispersed therein by, for example, stirring. The molten homogeneous mixture is then poured into convenient-sized

25 molds and allowed to cool and solidify.

Powders and tablets preferably contain between about 5% to about 70% by weight of the active ingredient. Suitable carriers include, for example, magnesium carbonate, magnesium stearate, talc, lactose, sugar,

30 pectin, dextrin, starch, tragacanth, methyl cellulose,

sodium carboxymethyl cellulose, a low-melting wax, cocoa butter and the like.

The pharmaceutical compositions can include the formulation of the active compound with encapsulating material as a carrier providing a capsule in which the active component (with or without other carriers) is surrounded by a carrier, which is thus in association with it. In a similar manner, cachets are also included. Tablets, powders, cachets, and capsules can be used as solid dosage forms suitable for oral administration.

Liquid pharmaceutical compositions include, for example, solutions suitable for oral or parenteral administration, or suspensions, and emulsions suitable for oral administration. Sterile water solutions of the active component or sterile solutions of the active component in solvents comprising water, ethanol, or propylene glycol are examples of liquid compositions suitable for parenteral administration.

Sterile solutions can be prepared by dissolving the active component in the desired solvent system, and then passing the resulting solution through a membrane filter to sterilize it or, alternatively, by dissolving the sterile compound in a previously sterilized solvent under sterile conditions.

Aqueous solutions for oral administration can be prepared by dissolving the active compound in water and adding suitable flavorants, coloring agents, stabilizers, and thickening agents as desired. Aqueous suspensions for oral use can be made by dispersing the finely divided active component in water together with a viscous material such as natural or synthetic gums,

resins, methyl cellulose, sodium carboxymethyl cellulose, and other suspending agents known to the pharmaceutical formulation art.

Preferably, the pharmaceutical composition is
5 in unit dosage form. In such form, the composition is divided into unit doses containing appropriate quantities of the active tetracyclic benzimidazole compound. The unit dosage form can be a packaged preparation, the package containing discrete quantities of the
10 preparation, for example, packeted tablets, capsules, and powders in vials or ampules. The unit dosage form can also be a capsule, cachet, or tablet itself, or it can be the appropriate number of any of these packaged forms.

As pharmaceutical compositions for treating
15 infections, pain, or any other indication the compounds of the present invention are generally in a pharmaceutical composition so as to be administered to a subject at dosage levels of from 0.7 to 7000 mg per day, and preferably 1 to 500 mg per day, for a normal human
20 adult of approximately 70 kg of body weight, this translates into a dosage of from 0.01 to 100 mg/kg of body weight per day. The specific dosages employed, however, can be varied depending upon the requirements of the patient, the severity of the condition being treated,
25 and the activity of the compound being employed. The determination of optimum dosages for a particular situation is within the skill of the art.

The compounds of and combinatorial libraries of the invention can be prepared as set forth in Figure 1
30 and as described below.

Variant tetracyclic benzimidazole derivative compounds and combinatorial libraries can be prepared in order to achieve a high level of diversity. For instance, a protected amino acid can be coupled to amine
5 compound and then deprotected, resulting in a carboxamido substituted amino compound having a substituent of the formula $\text{-NH-C(O)-C(variable group)-NH}_2$ (see step 1 of Figure 1).

The amine compound can be attached to solid
10 support, such as a functionalized resin (e.g., methylbenzhydrylamine (MBHA)).

The carboxamido substituted amino compound can then be coupled to a phenyl compound with a nitro and a halo group at ortho positions, resulting in a phenyl
15 compound substituted with a nitro group and a monosubstituted amino group. The phenyl compound being coupled can also have one to four additional substituents, such as carboxyl, halo, alkyl, etc. (see steps 2 and 3 of Figure 1).

20 Where the phenyl compound also has a carboxyl substituent, this substituent can be reacted with a (i) monosubstituted amine; (ii) disubstituted amine; (iii) cyclic imide; or (iv) alcohol; resulting, respectively, in a (i) monosubstituted carboxamido
25 substituent; (ii) disubstituted carboxamido substituent; (iii) cyclic imido carbonyl substituent; or (iv) ester substituent attached to the phenyl compound (see step 4 of Figure 1). It should be understood that such a substituent can be at any one to four of the available
30 positions on the phenyl ring.

The nitro group of the phenyl compound can be reduced (see step 5 of Figure 1). The resulting compound can be coupled with a phenyl compound that is substituted with an aldehyde group and a nitro group at meta positions on the phenyl ring, resulting in a phenyl substituted benzimidazole derivative compound having a nitro substituted phenyl substituent (see step 6 of Figure 1). The phenyl compound that is substituted with an aldehyde group and a nitro group can also be substituted with one to four leaving groups at the one to four remaining positions on the phenyl ring (see, for example, the fluoro group of the phenyl compound between steps 5 and 6 of Figure 1).

Where the phenyl group has a leaving group, it can be reacted with a monosubstituted amine, a disubstituted amine, a monosubstituted thiol and an alcohol, resulting, respectively, in a monosubstituted amino, disubstituted amino, monosubstituted thio or ether moiety on the phenyl ring (see step 7 of Figure 1).

The nitro group of the benzimidazole derivative compound (see step 6) can be reduced, resulting in a tetracyclic benzimidazole derivative compound (see steps 8 and 9 of Figure 1). In addition, the imino group in the resulting seven-member ring can be substituted. For example, the imino group can be alkylated with an alkyl halide or substituted alkyl halide.

Resin-bound tetracyclic benzimidazole derivative compounds can be cleaved by treating them, for example, with HF gas (see Example 1, Step 6; and steps 7 to 8 of Figure 1). The compounds can then be extracted from the spent resin, for example, with AcOH (see Example 1, Step 6).

Tetracyclic benzimidazole derivative compounds and libraries, such as those of the present invention, can be made utilizing individual polyethylene bags, referred to as "tea bags" (see Houghten et al., *Proc. Natl. Acad. Sci. USA* 82: 5131 (1985); *Biochemistry*, 32:11035 (1993); and U.S. Patent No. 4,631,211, all of which are incorporated herein by reference).

The nonsupport-bound combinatorial libraries can be screened as single compounds. In addition, the
10 nonsupport-bound combinatorial libraries can be screened as mixtures in solution in assays such as radio-receptor inhibition assays, anti-bacterial assays, anti-fungal assays, calmodulin-dependent phosphodiesterase (CaMPDE) assays and phosphodiesterase (PDE) assays, as described
15 in detail below. Deconvolution of highly active mixtures can then be carried out by iterative or positional scanning methods. These techniques, the iterative approach or the positional scanning approach, can be utilized for finding other active compounds within the
20 combinatorial libraries of the present invention using any one of the below-described assays or others well known in the art.

The iterative approach is well-known and is set forth in general in Houghten et al., *Nature*, 354, 84-86
25 (1991) and Dooley et al., *Science*, 266, 2019-2022 (1994), both of which are incorporated herein by reference. In the iterative approach, for example, sub-libraries of a molecule having three variable groups are made wherein the first variable is defined. Each of the compounds
30 with the defined variable group is reacted with all of the other possibilities at the other two variable groups. These sub-libraries are each tested to define the identity of the second variable in the sub-library having

the highest activity in the screen of choice. A new sub-library with the first two variable positions defined is reacted again with all the other possibilities at the remaining undefined variable position. As before, the identity of the third variable position in the sub-library having the highest activity is determined. If more variables exist, this process is repeated for all variables, yielding the compound with each variable contributing to the highest desired activity in the screening process. Promising compounds from this process can then be synthesized on larger scale in traditional single-compound synthetic methods for further biological investigation.

The positional-scanning approach has been described for various combinatorial libraries as described, for example, in R. Houghten et al. PCT/US91/08694 and U.S. Patent 5,556,762, both of which are incorporated herein by reference. In the positional scanning approach, sublibraries are made defining only one variable with each set of sublibraries and all possible sublibraries with each single variable defined (and all other possibilities at all of the other variable positions), made and tested. From the instant description one skilled in the art could synthesize combinatorial libraries wherein two fixed positions are defined at a time. From the testing of each single-variable defined combinatorial library, the optimum substituent at that position can be determined, pointing to the optimum or at least a series of compounds having a maximum of the desired biological activity. Thus, the number of sublibraries for compounds with a single position defined will be the number of different substituents desired at that position, and the number of all the compounds in each sublibrary will be the product

of the number of substituents at each of the other variables.

Individual compounds and pharmaceutical compositions containing the compounds, as well as methods of using the same, are included within the scope of the present invention. The compounds of the present invention can be used for a variety of purposes and indications and as medicaments for any such purposes and indications. For example, tetracyclic benzimidazole derivative compounds of the present invention can be used as pesticides, acaricides, receptor agonists or antagonists and antimicrobial agents, including antibacterial or antiviral agents. For example, the libraries can be screened in any variety of melanocortin receptor and related activity assays, such as those detailed below as well as others known in the art. Additionally, the subject compounds can be useful as analgesics. Assays which can be used to test the biological activity of the instant compounds include antimicrobial assays, a competitive enzyme-linked immunoabsorbent assay and radio-receptor assays, as described below.

The melanocortin (MC) receptors are a group of cell surface proteins that mediate a variety of physiological effects, including regulation of adrenal gland function such as production of the glucocorticoids cortisol and aldosterone; control of melanocyte growth and pigment production; thermoregulation; immunomodulation; and analgesia. Five distinct MC receptors have been cloned and are expressed in a variety of tissues, including melanocytes, adrenal cortex, brain, gut, placenta, skeletal muscle, lung, spleen, thymus, bone marrow, pituitary, gonads and

adipose tissue (Tatro, Neuroimmunomodulation 3:259-284 (1996)). Three MC receptors, MCR-1, MCR-3 and MCR-4, are expressed in brain tissue (Xia et al., Neuroreport 6:2193-2196 (1995)).

5 A variety of ligands termed melanocortins function as agonists that stimulate the activity of MC receptors. The melanocortins include melanocyte-stimulating hormones (MSH) such as α -MSH, β -MSH and γ -MSH, as well as adrenocorticotrophic hormone
10 (ACTH). Individual ligands can bind to multiple MC receptors with differing relative affinities. The variety of ligands and MC receptors with differential tissue-specific expression likely provides the molecular basis for the diverse physiological effects of
15 melanocortins and MC receptors. For example, α -MSH antagonizes the actions of immunological substances such as cytokines and acts to modulate fever, inflammation and immune responses (Catania and Lipton, Annals N. Y. Acad. Sci. 680:412-423 (1993)).

20 The role of certain specific MC receptors in some of the physiological effects described above for MC receptors has been elucidated. For example, MCR-1 is involved in pain and inflammation. MCR-1 mRNA is expressed in neutrophils (Catania et al., Peptides
25 17:675-679 (1996)). The anti-inflammatory agent α -MSH was found to inhibit migration of neutrophils. Thus, the presence of MCR-1 in neutrophils correlates with the anti-inflammatory activity of α -MSH.

 An interesting link of MC receptors to
30 regulation of food intake and obesity has recently been described. The brain MC receptor MCR-4 has been shown to function in the regulation of body weight and food

intake. Mice in which MCR-4 has been knocked out exhibit weight gain (Huszar et al., Cell 88:131-141 (1997)). In addition, injection into brain of synthetic peptides that mimic melanocortins and bind to MCR-4 caused suppressed
5 feeding in normal and mutant obese mice (Fan et al., Nature 385:165-168 (1997)). These results indicate that the brain MC receptor MCR-4 functions in regulating food intake and body weight.

Due to the varied physiological activities of
10 MC receptors, high affinity ligands of MC receptors could be used to exploit the varied physiological responses of MC receptors by functioning as potential therapeutic agents or as lead compounds for the development of therapeutic agents. Furthermore, due to the effect of MC
15 receptors on the activity of various cytokines, high affinity MC receptor ligands could also be used to regulate cytokine activity.

A variety of assays can be used to identify or characterize MC receptor ligands of the invention. For
20 example, the ability of a tetracyclic benzimidazole derivative compound to compete for binding of a known MC receptor ligand can be used to assess the affinity and specificity of a tetracyclic benzimidazole compound for one or more MC receptors. Any MC receptor ligand can be
25 used so long as the ligand can be labeled with a detectable moiety. The detectable moiety can be, for example, a radiolabel, fluorescent label or chromophore, or any detectable functional moiety so long as the MC receptor ligand exhibits specific MC receptor binding. A
30 particularly useful detectable MC receptor ligand for identifying and characterizing other MC receptor ligands is ¹²⁵I-HP 467, which has the amino acid sequence Ac-Nle-Gln-His-(p(I)-D-Phe)-Arg-(D-Trp)-Gly-NH₂ and is

described in Dooley et al., "Melanocortin Receptor
Ligands and Methods of Using Same," U.S. patent
application 09/027,108, filed February 20, 1998, which is
incorporated herein by reference. HP 467 is a para-
5 iodinated form of HP 228.

Using assay methods such as those described
above, binding kinetics and competition with radiolabeled
HP 467 can confirm that tetracyclic benzimidazole
compounds of the invention bind to one or more MC
10 receptors. Furthermore, tetracyclic benzimidazole
derivative compounds of the invention can exhibit a range
of affinities and specificity for various MC receptors.

The invention provides MC receptor ligands that
can bind to several MC receptors with similar affinity.
15 In addition, the invention also provides MC receptor
ligands that can be selective for one or more MC
receptors. As used herein, the term "selective" means
that the affinity of a MC receptor ligand differs between
one MC receptor and another by about 10-fold, generally
20 about 20- to 50-fold, and particularly about 100-fold.
In some cases, a MC receptor ligand having broad
specificity is desired. In other cases, it is desirable
to use MC receptor ligands having selectivity for a
particular MC receptor. For example, MCR-1 ligands are
25 particularly useful for treating pain and inflammation,
whereas MCR-4 ligands are useful for treating obesity.
The binding characteristics and specificity of a given MC
receptor ligand can be selected based on the particular
disease or physiological effect that is desired to be
30 altered.

Another assay useful for identifying or
characterizing MC receptor ligands measures signaling of

MC receptors. MC receptors are G protein-coupled receptors that couple to adenylate cyclase and produce cAMP. Therefore, measuring cAMP production in a cell expressing a MC receptor and treated with a MC receptor
5 ligand can be used to assess the function of the MC receptor ligand in activating a MC receptor.

Ligands for MC-3 that can alter the activity of an MC-3 receptor can be useful for treating sexual dysfunction and other conditions or conditions associated
10 with MC-3 such as inflammation. Other MC-3-associated conditions that can be treated with the MC-3 receptor ligands include disuse deconditioning; organ damage such as organ transplantation or ischemic injury; adverse reactions associated with cancer chemotherapy; diseases
15 such as atherosclerosis that are mediated by free radicals and nitric oxide action; bacterial endotoxic sepsis and related shock; adult respiratory distress syndrome; and autoimmune or other patho-immunogenic diseases or reactions such as allergic reactions or
20 anaphylaxis, rheumatoid arthritis, inflammatory bowel disease, ulcerative colitis, glomerulonephritis, systemic lupus erythematosus, transplant atherosclerosis and parasitic mediated immune dysfunctions such as Chagas's Disease.

25 The invention further provides a method for treating an MC-3-associated condition in a subject. The term "MC-3-associated condition" includes any condition or condition mediated by MC-3 or can be affected by binding an MC-3 ligand. Such conditions include
30 inflammation and sexual dysfunction.

The term "sexual dysfunction" herein means any condition that inhibits or impairs normal sexual

function, including coitus. However, the term need not be limited to physiological conditions, but may include psychogenic conditions or perceived impairment without a formal diagnosis of pathology.

5 In males, sexual dysfunction includes erectile dysfunction. The term "erectile dysfunction" or "impotence" means herein the inability or impaired ability to attain or sustain an erection that would be of satisfactory rigidity for coitus. Sexual dysfunction in
10 males can also include premature ejaculation and priapism, which is a condition of prolonged and sometimes painful erection unrelated to sexual activity, often associated with sickle-cell disease.

 In females, sexual dysfunction includes sexual
15 arousal disorder. The term "sexual arousal disorder" means herein a persistent or recurrent failure to attain or maintain the lubrication-swelling response of sexual excitement until completion of sexual activity. Sexual dysfunction in females can also include inhibited orgasm
20 and dyspareunia, which is painful or difficult coitus. Sexual dysfunction can also be manifested as inhibited sexual desire or inhibited lordosis behavior in animals.

 In addition, the ability of the compounds to inhibit bacterial growth, and therefore be useful to that
25 infection, can be determined by methods well known in the art. Compounds of the present invention were shown to have antimicrobial activity by the *in vitro* antimicrobial activity assay described below and, therefore, are useful as antimicrobial agents (see Example 16).

30 In addition, an exemplary *in vitro* antimicrobial activity assay is described in Blondelle

and Houghten, *Biochemistry* 30:4671-4678 (1991), which is incorporated herein by reference. In brief, *Staphylococcus aureus* ATCC 29213 (Rockville, MD) is grown overnight at 37°C in Mueller-Hinton broth, then re-
5 inoculated and incubated at 37°C to reach the exponential phase of bacterial growth (i.e., a final bacterial suspension containing 10^5 to 5×10^5 colony-forming units/ml). The concentration of cells is established by plating 100 μ l of the culture solution using serial
10 dilutions (e.g., 10^{-2} , 10^{-3} and 10^{-4}) onto solid agar plates. In 96-well tissue culture plates, compounds, individual or in mixtures, are added to the bacterial suspension at concentrations derived from serial two-fold dilutions ranging from 1500 to 2.9 μ g/ml. The plates are
15 incubated overnight at 37°C and the growth determined at each concentration by OD₆₂₀ nm. The IC₅₀ (the concentration necessary to inhibit 50% of the growth of the bacteria) can then be calculated.

The competitive ELISA method which can be used
20 here is a modification of the direct ELISA technique described previously in Appel et al., J. Immunol. 144:976-983 (1990), which is incorporated herein by reference. It differs only in the MAb addition step. Briefly, multi-well microplates are coated with the
25 antigenic peptide (Ac-GASPYPNLSNQQT-NH₂) at a concentration of 100 pmol/50 μ l. After blocking, 25 μ l of a 1.0 mg/ml solution of each mixture of a synthetic combinatorial library (or individual compound) is added, followed by MAb 125-10F3 (Appel et al., *supra*) (25 μ l per
30 well). The MAb is added at a fixed dilution in which the bicyclic guanidine in solution effectively competes for MAb binding with the antigenic peptide adsorbed to the plate. The remaining steps are the same as for direct ELISA. The concentration of compound necessary to

inhibit 50% of the MAb binding to the control peptide on the plate (IC_{50}) is determined by serial dilutions of the compound.

Alternative screening can be done with radio-
5 receptor assays. The radio-receptor assay, can be selective for any one of the μ , κ , or δ opiate receptors. Compounds of the present invention can be useful in vitro for the diagnosis of relevant opioid receptor subtypes, such as κ , in the brain and other tissue samples.
10 Similarly, the compounds can be used *in vivo* diagnostically to localize opioid receptor subtypes.

The radio-receptor assays are also an indication of the compounds' analgesic properties as described, for example, in Dooley et al., *Proc. Natl.*
15 *Acad. Sci.*, 90:10811-10815 (1993). For example, it can be envisioned that these compounds can be used for therapeutic purposes to block the peripheral effects of a centrally acting pain killer. For instance, morphine is a centrally acting pain killer. Morphine, however, has a
20 number of deleterious effects in the periphery which are not required for the desired analgesic effects, such as constipation and pruritus (itching). While it is known that the many compounds do not readily cross the blood-brain barrier and, therefore, elicit no central effect,
25 the subject compounds can have value in blocking the periphery effects of morphine, such as constipation and pruritus. Accordingly, the subject compounds can also be useful as drugs, namely as analgesics, or to treat pathologies associated with other compounds which
30 interact with the opioid receptor system.

Additionally, such compounds can be tested in a σ receptor assay. Ligands for the σ receptor can be

useful as antipsychotic agents, as described in Abou-Gharbia et al., *Annual Reports in Medicinal Chemistry*, 28:1-10 (1993).

Radio-receptor assays can be performed with
5 particulate membranes prepared using a modification of the method described in Pasternak et al., *Mol. Pharmacol.* 11:340-351 (1975), which is incorporated herein by reference. Rat brains frozen in liquid nitrogen can be obtained from Rockland (Gilbertsville, PA). The brains
10 are thawed, the cerebella removed and the remaining tissue weighed. Each brain is individually homogenized in 40 ml Tris-HCl buffer (50 mM, pH 7.4, 4°C) and centrifuged (Sorvall® RC5C SA-600: Du Pont, Wilmington, DE) (16,000 rpm) for 10 minutes. The pellets are
15 resuspended in fresh Tris-HCl buffer and incubated at 37°C for 40 minutes. Following incubation, the suspensions are centrifuged as before, the resulting pellets resuspended in 100 volumes of Tris buffer and the suspensions combined. Membrane suspensions are prepared
20 and used in the same day. Protein content of the crude homogenates generally range from 0.15-0.2 mg/ml as determined using the method described in Bradford, M.M., *Anal. Biochem.* 72:248-254 (1976), which is incorporated herein by reference.

25 Binding assays are carried out in polypropylene tubes, each tube containing 0.5 ml of membrane suspension. 8 nM of ³H-[D-Ala²,Me-Phe⁴,Gly-ol⁵]enkephalin (DAMGO) (specific activity = 36 Ci/mmol, 160,000 cpm per tube; which can be obtained from Multiple Peptide
30 Systems, San Diego, CA, through NIDA drug distribution program 271-90-7302) and 80 µg/ml of bicyclic guanidine, individual or as a mixture and Tris-HCl buffer in a total volume of 0.65 ml. Assay tubes are incubated for 60

mins. at 25°C. The reaction is terminated by filtration through GF-B filters on a Tomtec harvester (Orange, CT). The filters are subsequently washed with 6 ml of Tris-HCl buffer, 4°C. Bound radioactivity is counted on a

5 Pharmacia Biotech Betaplate Liquid Scintillation Counter (Piscataway, NJ) and expressed in cpm. To determine inter- and intra-assay variation, standard curves in which ³H-DAMGO is incubated in the presence of a range of concentrations of unlabeled DAMGO (0.13-3900 nM) are

10 generally included in each plate of each assay (a 96-well format). Competitive inhibition assays are performed as above using serial dilutions of the bicyclic guanidines, individually or in mixtures. IC₅₀ values (the concentration necessary to inhibit 50% of ³H-DAMGO

15 binding) are then calculated. IC₅₀ values of less than 1000 nM are indicative of highly active opioid compounds which bind to the μ receptor, with particularly active compounds having IC₅₀ values of 100 nM or less and the most active compounds with values of less than 10 nM.

20 As opposed to this μ receptor selective assay, which can be carried out using ³H-DAMGO as radioligand, as described above, assays selective for κ receptors can be carried out using [³H]-U69,593 (3 nM, specific activity 62 Ci/mmol) as radioligand. Assays selective for δ opiate

25 receptors can be carried out using tritiated DSLET ([D-Ser², D-Leu⁵]-threonine-enkephalin) as radioligand. Assays selective for the σ opiate receptor can use radiolabeled pentazocine as ligand.

Screening of combinatorial libraries and

30 compounds of the invention can be done with an anti-fungal assay. Compounds of the present invention can be useful for treating fungal infections.

Screening of combinatorial libraries and compounds of the invention also can be done with a calmodulin-dependent phosphodiesterase (CaMPDE) assay. Compounds of the present invention can be useful as
5 calmodulin antagonists.

Calmodulin (CaM), which is the major intracellular calcium receptor, is involved in many processes that are crucial to cellular viability. In particular, calmodulin is implicated in calcium-
10 stimulated cell proliferation. Calmodulin antagonists are, therefore, useful for treating conditions associated with increased cell proliferation, for example, cancer. In addition, calmodulin antagonists such as compounds of the subject invention are useful both in vitro and in
15 vivo for identifying the role of calmodulin in other biological processes. The disadvantages of known antagonists such as trifluoperazine and N-(4-aminobutyl)-5-chloro-2-naphthalenesulfonamide (W13) include their non-specificity and toxicity. In contrast, advantages of
20 the combinatorial libraries and compounds of the subject invention as calmodulin antagonists include their reduced flexibility and ability to generate broader conformational space of interactive residues as compared to their linear counterparts.

25 An example of an assay that identifies CaM antagonists is a CaMPDE assay. In brief, samples are mixed with 50 μ l of assay buffer (360 mM Tris, 360 mM Imidazole, 45 mM $\text{Mg}(\text{CH}_3\text{COO})_2$, pH 7.5) and 10 μ l of CaCl_2 (4.5 mM) to a final volume of 251 μ l. 25 μ l of
30 calmodulin stock solution (Boehringer Mannheim; 0.01 $\mu\text{g}/\mu\text{l}$) is then added and the samples then sit at room temperature for 10 minutes. 14 μ l of PDE (Sigma; 2 Units dissolved in 4 ml of water; stock concentration:

0.0005 Units/ μ l) is then added, followed by 50 μ l of 5'-nucleotidase (Sigma; 100 Units dissolved in 10 ml of 10 mM Tris-HCl containing 0.5 mM $\text{Mg}(\text{CH}_3\text{COO})_2$, pH 7.0; stock concentration: 10 Units/ml). The samples are then

5 incubated for 10 minutes at 30°C. 50 μ l of adenosine 3',5'-cyclic monophosphate (cAMP) (20 mM in water at pH 7.0) is added, the samples incubated for 1 hour at 30°C and then vortexed. 200 μ l of trichloroacetic acid (TCA) (55% in water) is added to a 200 μ l sample aliquot, which

10 is then vortexed and centrifuged for 10 minutes. 80 μ l of the resulting supernatants of each sample is transferred to a 96-well plate, with 2 wells each containing 80 μ l of each sample. 80 μ l of ammonium molybdate (1.1% in 1.1N H_2SO_4) is then added to all the

15 wells, and the OD of each were determined at 730nm, with the values later subtracted to the final OD reading. 16 μ l of reducing agent (6g sodium bisulfite, 0.6g sodium sulfite and 125mg of 1-amino-2-naphtol-4-sulfonic acid in 50ml of water) is then added to one of each sample

20 duplicate and 16 μ l of water is added to the other duplicate. After sitting for 1 hour at room temperature, the OD of each well is determined at 730nm. The percent inhibition of calmodulin activity is then calculated for each sample, using as 0% inhibition a control sample

25 containing all reagents without any test samples and as 100% inhibition a control sample containing test samples and all reagents except calmodulin. In addition, the percent inhibition of phosphodiesterase activity was determined by following a similar protocol as the CaMPDE

30 assay described above, except not adding calmodulin to the sample mixture and calculating the percent inhibition by using as 0% inhibition a control reagent without any test samples and as 100% inhibition a control sample containing test samples and all reagents except cAMP.

The following examples are provided to illustrate but not limit the present invention. In the examples, the following abbreviations have the corresponding meanings:

- 5 MBHA : 4-methylbenzhydramine;
DMF : dimethylformamide;
HoBt : 1-hydroxybenzotriazole;
DMSO : dimethylsulfoxide;
Boc : tert-butoxycarbonyl;
- 10 FMOC : 9-fluorenyl-methoxycarbonyl;
DMAP : 4-dimethylamino-pyridine;
DIC : N,N'-diisopropylcarbodiimide;
TFA : trifluoroacetic acid;
DIEA : diisopropylethylamine;
- 15 DCM : dichloromethane;
TMOF: trimethylorthoformate;
HATU : azabenzotriazolyl-N,N,N',N'-tetramethyluronium
hexafluorophosphate;

EXAMPLE 1

- 20 **Preparation of a combinatorial library of 70 tetracyclic bezimidazole derivative compounds (pyrrolidinyl 7-phenylmethyl-2-substituted-5H-benzimidazol[1,2,d][1,4]benzodiazepin-6(7H)-one-10-Carboxamides)**

- 25 This example describes 70 substituted amino variations at the R⁷ position, the side chain of phenylalanine (Ph-CH₂) providing the R¹ position, pyrrolidinocarbonyl at the R⁴ position and hydrogen at the remaining R positions.

Step 1:**Coupling of N-protected amino acid to MBHA resin**

1.0 g of MBHA resin (1.3 meq/g) was placed in a
5 porous polypropylene packet (Tea-bag, 60mm x 60mm, 65 μ).
The packet was washed with 5% DIEA/DCM (2 X 60 mL) in a
65 mL plastic bottle. DMF (40 mL), Boc-phenylalanine
(3.45g, 13 mmol), DIC (2.52g, 20 mmol), HOBt (1.75g, 13
mmol) were added sequentially. After shaking for 12
10 hours, the packet was washed alternatively with DMF (40
mL) and MeOH (40 mL) for 3 cycles followed by DCM (40
mL) and MeOH (40 mL). The packet was dried in air for
1h. The packet was shaken with 55% TFA/DCM (40 mL) at
room temperature for 40 minutes and washed with DCM (3 X
15 40 mL), 5% DIEA/DCM (2 X 40 mL) and MeOH (3 X 40 mL).

Step 2:**N-Arylation with 4-fluoro-3-nitrobenzoic acid**

The packet resulting from the reaction described
in step 1 was heated in a solution of
20 4-fluoro-3-nitrobenzoic acid (2.40g, 13 mmol) and DIEA
(1.64g, 13 mmol) in N-methylpyrrolidinone (40 mL) at
70° C for 24 hours. The packet was washed alternatively
with DMF (40 mL) and MeOH (40 mL) for 3 cycles followed
by washing with DCM (40 mL) and MeOH (2 X 40 mL). The
25 packet was dried in air for 2 hours.

Step 3:**Coupling pyrrolidine:**

The packet resulting from the reaction described
in step 2 was shaken with a solution of pyrrolidine
30 (0.92 g, 13 mmol), DIC (2.52g, 20 mmol) and HOBt (1.75g,

13 mmol) in DMF (40 mL) for 24 hours. The packet was washed alternatively with DMF (40 mL) and MeOH (40 mL) for 3 cycles followed by DCM (40 mL) and MeOH (2 X 40 mL). The packet was dried in air for 2 hours.

5

Step 4:**Reduction of the nitro group to amine.**

The packet resulting from the reaction described in step 3 was shaken with a 2.0 M solution of tin(II) chloride dihydrate in N-Methylpyrrolidinone (40 mL) for 10 24 hours at room temperature. The packet was washed with DMF (6 X 40 mL), 10% DIEA/DCM (4 X 40 mL), MeOH, (2 X 40 mL), DMF (40 mL), MeOH (40 mL), DCM (2 X 40 mL) and MeOH (2 X 40 mL) and dried in air for 2 hours.

Step 5:

15

Reaction with aldehyde to form benzimidazole

The packet resulting from the reaction described in step 4 was heated in a solution of 5-fluoro-2-nitrobenzaldehyde (2.21g, 13 mmol) in N-methylpyrrolidinone (20 mL) and acetic acid (20 mL) at 20 70° C for 72 hours. The packet was washed alternatively with DMF (40 mL) and MeOH (40 mL) for 3 cycles followed by washing with DCM (40 mL) and MeOH (2 X 40 mL). The packet was dried in air for 2 hours.

Step 6:

25

Displacement of fluoro substituent by one of 70 amines

The packet resulting from the reaction described in step 5 was cut open and the resin was suspended in N-methylpyrrolidinone (30 mL). The suspension was

distributed equally into 70 wells of a microtiter plate (2mL X 96). One of 70 amines in N-methylpyrrolidinone (100 μ L X 1.0 M) were added to each well. The plate was tightly capped, shaken and incubated at 75° C for 72
5 hours. The resin was washed alternatively with DMF (3 X 1 mL/well) and MeOH (2 X 1 mL/well).for 5 cycles and MeOH (5 X 1 mL/well). The plate was dried in air for two days and under vacuum for 4 hours. To cleave the resulting compounds, the plate was treated with gaseous HF at room
10 temperature for 2 hours. After complete removal of HF under a nitrogen stream followed by vacuum, the plate was extracted with AcOH (4 x 0.5 mL/well). The extractions were then lyophilized. The 70 amines were as follows:

15 1-(2-furoyl)-piperazine
1-(2-pyridyl)piperazine
1-(4-fluorophenyl)piperazine
piperazine
N-acetyleneethylenediamine
20 ethylenediamine
ethyl isonipecotate
N-(3-aminopropyl)morpholine
3-(trifluoromethyl)benzylamine
cyclohexylamine
p-xylylenediamine
25 1-methyl-4-(methylamino)piperidine
1-(ethoxycarbonylmethyl)piperazine
 β -alanine ethylester
N-(2-aminoethyl)morpholine
cyclooctylamine
30 3-fluorophenethylamine
2-fluorophenethylamine
N-(3-trifluoromethylphenyl)piperazine
3,3,5-trimethylcyclohexylamine
1-benzylpiperazine

- ethyl nipecotate
2-(2-methylaminoethyl)pyridine
2-(2-aminoethyl)pyridine
4-amino-1-benzylpiperidine
5 1,8-diamino-3,6-dioxaoctane
tyramine
N,N-dimethylethylenediamine
N-methylphenethylamine
diethylamine
10 4-(trifluoromethyl)benzylamine
2-(aminomethyl)-1-ethylpyrrolidine
N,N-dimethyl-1,3-propanediamine
N,N,N'-trimethyl-1,3-propanediamine
3,3'-bis(dimethylamino)-dipropylamine
15 1-(4-nitrophenyl)-piperazine
4-piperazinoacetophenone
3-(aminomethyl)pyridine
ethyl 4-amino-1-piperidinecarboxylate
thiomorpholine
20 m-xylylenediamine
N,N-diethyl-2-butene-1,4-diamine
1-(4-methoxyphenyl)-2-methylpiperazine
N-(3,4-dichlorophenyl)piperazine
tetrahydrofurfurylamine
25 1-acetylpiperazine
1,3-diaminopropane
2,3-dimethoxybenzylamine
2-methyl-1-(3-methylphenyl)piperazine
1,3,3-trimethyl-6-azabicyclo[3.2.1]octane
30 1-(5-chloro-ortho-tolyl)-piperazine
hexamethyleneimine
cycloheptylamine
3-acetamidopyrrolidine
1-benzyl-3-aminopyrrolidine
35 1-(2-aminoethyl)piperidine

1-ethoxycarbonylpiperazine
4-amino-2,2,6,6-tetramethylpiperidine
N-methylbenzylamine
2-ethoxyethylamine
5 3-(methylthio)propylamine
4-fluorobenzylamine
butylamine
isonipecotamide
N,N-diethyl-n'-methylethylenediamine
10 1-(3-aminopropyl)-2-pipecoline
morpholine
1-(2,5-dimethylphenyl)piperazine
1-(2,3-dimethylphenyl)-piperazine
cyclopropylamine

15

EXAMPLE 2

**Preparation of a combinatorial library of 83 tetracyclic
benzimidazole derivative compounds**

(bis(methoxyethyl)amino
20 7-(3-Indolylmethyl)-2-substituted-5H-benzimidazol[1,2,d][
1,4]benzodiazepin-6(7H)-one-10-carboxamides)

Using the same experimental procedures as
described in Example 1, an additional combinatorial
library of 83 tetracyclic benzimidazole derivative
25 compounds were synthesized. This example describes 83
substituted amino variations at the R⁷ position, the side
chain of tryptophan providing the R¹ position,
bis(methoxyethyl)aminocarbonyl at the R⁴ position and
hydrogen at the remaining R positions. The 83 amines
30 used were as follows:

1-(2-furoyl)piperazine
1-(2-pyridyl)piperazine
1-(4-fluorophenyl)piperazine
piperazine
35 N-acetyleneethylenediamine

- ethylenediamine
- tryptamine
- ethyl isonipecotate
- ethanolamine
- 5 4-(3-aminopropyl)morpholine
- p-phenylenediamine
- 3-(trifluoromethyl)benzylamine
- N-ethylmethylaniline
- cyclohexylamine
- 10 p-xylylenediamine
- 1-methyl-4-(methylaniline)piperidine
- 1-(ethoxycarbonylmethyl)piperazine
- beta alanine-ethyl ester
- 4-(2-aminoethyl)morpholine
- 15 cyclooctylamine
- 3-fluorophenethylamine
- 2-fluorophenethylamine
- N-(3-trifluoromethylphenyl)piperazine
- 3,3,5-trimethylcyclohexylamine
- 20 1-benzylpiperazine
- ethyl nipecotate
- 2-(2-methylaminoethyl)pyridine
- 2-(2-aminoethyl)pyridine
- 4-amino-1-benzylpiperidine
- 25 decahydroquinoline
- trans-1,4-diaminocyclohexane
- 4-methoxybenzylamine
- 2,2-(ethylenedioxy)bis(ethylamine)
- tyramine
- 30 N,N-dimethylethylenediamine
- N-methylphenethylamine
- diethylamine
- 2-(aminomethyl)-1-ethylpyrrolidine
- 3-dimethylaminopropylamine
- 35 N,N,N'-trimethyl-1,3-propanediamine

- 3,3'-bis(dimethylamino)-dipropylamine
1-(4-nitrophenyl)piperazine
4-piperazinoacetophenone
3-(aminomethyl)pyridine
5 2-(aminomethyl)pyridine
ethyl 4-amino-1-piperidinecarboxylate
thiomorpholine
m-xylylenediamine
N,N-diethyl-2-butene-1,4-diamine
10 N-methyl-N-propylamine
N-butylbenzylamine
1-(4-methoxyphenyl)-2-methylpiperazine
N-(3,4-dichlorophenyl)piperazine
tetrahydrofurfurylamine
15 1-acetylpiperazine
1,3-diaminopropane
2,3-dimethoxybenzylamine
2-methyl-1-(3-methylphenyl)piperazine
1,3,3-trimethyl-6-azabicyclo(3.2.1)octane
20 1-(5-chloro-ortho-tolyl)-piperazine
hexamethyleneimine
N,N,N'-trimethylethylenediamine
cycloheptylamine
3-acetamidopyrrolidine
25 1-benzyl-3-aminopyrrolidine
bis(2-methoxyethyl)amine
N-(2-aminoethyl)piperadine
ethyl 1-piperazine carboxylate
4-amino-2,2,6,6-tetramethylpiperadine
30 N-benzylmethylamine
2-ethoxyethylamine
3-(2-ethylhexyloxy)propylamine
3-methylthiopropylamine
4-fluorobenzylamine
35 cyclopentylamine

- ethyl 4-amino-1-piperidinecarboxylate
- pyrrolidine
- butylamine
- isonipecotamide
- 5 N,N-diethyl-N'-methylethylenediamine
- 1-(3-aminopropyl)-2-pipecoline
- bis(3-aminopropyl)ether
- cyclopropylamine

EXAMPLE 3

- 10 **Preparation of a combinatorial library of tetracyclic benzimidazole derivative compounds (pyrrolidinyl 7-Phenylmethyl-2-substituted-5H-benzimidazol[1,2,d][1,4]benzodiazepin-6(7H)-one-10-carboxamides)**

- Using the same experimental procedures as
- 15 described in Example 1, an additional combinatorial library of 8 tetracyclic benzimidazole derivative compounds were synthesized. This example describes 8 substituted thio variations at the R⁷ position, the side chain of phenylalanine providing the R¹ position,
- 20 pyrrolidinocarbonyl at the R⁴ position and hydrogen at the remaining R positions. The 8 thiols used were as follows:

- 5-phenyl-1H-1,2,4-triazole-3-thiol
- 6-mercaptonicotinic acid
- 25 2-mercaptoimidazole
- 4-6-dimethyl-2-mercaptopyrimidine
- 2-mercapto-5-methyl-1,3,4-thiadiazole
- 3-mercapto-1,2,4-triazole
- 3-mercapto-4-methyl-1,2,4-triazole
- 30 2-mercaptopyridine

EXAMPLE 4

Preparation of a combinatorial library of tetracyclic benzimidazole derivative compounds

- (1'-Ethylpyrrolidino-2'-methylamino**
5 **2-Morpholino-7-substituted-5H-benzimidazol[1,2,d][1,4]benzodiazepin-6(7H)-one-10-carboxamides)**

Using the same experimental procedures as described in Example 1, an additional combinatorial library of 15 tetracyclic benzimidazole derivative
10 compounds were synthesized. This example describes the side chain of 15 different amino acids providing the R¹ position, 2-(aminomethyl)-1-ethylpyrrolidinocarbonyl at the R⁴ position, 1-morpholino at the R⁷ position and hydrogen at the remaining R positions. The 15 amino
15 acids used were as follows:

- Boc-glycine
Boc-L-alanine
Boc-L-valine
Boc-L-isoleucine
20 Boc-L-glutamine
Boc-L-methionine
Boc-L-phenylglycine
Boc-L-phenylalanine
Boc-D-phenylalanine
25 Boc-L-cyclohexylalanine
Boc-O-methyl-L-tyrosine
Boc-4-chloro-L-phenylalanine
Boc-Nⁱⁿ-formal-L-tryptophan
N^α-Boc-N^ε-trifluoroacetyl-L-lysine
30 N^α-Boc-N⁹-4-tosyl-L-arginine

EXAMPLE 5

Preparation of a combinatorial library of tetracyclic benzimidazole derivative compounds

(4'-(2-Furoyl)piperazinyl

- 5 **2-Morpholino-7-substituted-5H-benzimidazol[1,2,d][1,4]benzodiazepin-6(7H)-one-10-carboxamides)**

Using the same experimental procedures as described in Example 1, an additional combinatorial library of 15 tetracyclic benzimidazole derivative
10 compounds were synthesized. This example describes the side chain of 15 different amino acids providing the R¹ position, 1-(2-furoyl)piperazinocarbonyl at the R⁴ position, 1-morpholino at the R⁷ position and hydrogen at the remaining R positions. The 15 amino acids used were
15 as follows:

- Boc-glycine
- Boc-L-alanine
- Boc-L-valine
- Boc-L-isoleucine
- 20 Boc-L-glutamine
- Boc-L-methionine
- Boc-L-phenylglycine
- Boc-L-phenylalanine
- Boc-D-phenylalanine
- 25 Boc-L-cyclohexylalanine
- Boc-O-methyl-L-tyrosine
- Boc-4-chloro-L-phenylalanine
- Boc-Nⁱⁿ-formal-L-tryptophan
- N^o-Boc-N^e-trifluoroacetyl-L-lysine
- 30 N^o-Boc-N^q-4-tosyl-L-arginine

EXAMPLE 6**Preparation of a combinatorial library of tetracyclic benzimidazole derivative compounds**

5 (2-Morpholino-7-phenylmethyl-5H-benzimidazol[1,2,d][1,4] benzodiazepin-6 (7H)-one-10-carboxamides)

Using the same experimental procedures as described in Example 1, an additional combinatorial library of 43 tetracyclic benzimidazole derivative compounds were synthesized. This example describes 43 substituted amino variations as building blocks for the R⁴ position, the side chain of L-phenylalanine providing the R¹ position, 1-morpholino at the R⁷ position and hydrogen at the remaining R positions. The 43 amines used were as follows:

- 15 2-(aminomethyl)-1-ethylpyrrolidine
- 2-aminothiazole
- methyl 6-aminocaproate
- beta-alanine ethyl ester
- pyrrolidine
- 20 N-methylhomopiperazine
- 1-(4-fluorophenyl)piperazine
- 1-hydroxyethylethoxypiperazine
- 3-(methylthio)aniline
- 1-(2-pyridyl)piperazine
- 25 1-methyl-4-(methylamino)piperidine
- 2-(2-aminoethyl)pyridine
- 4-hydroxypiperidine
- 2-ethanolamine
- 4-(trifluoromethyl)benzylamine
- 30 4-amino-2,2,6,6-tetramethylpiperidine
- ethyl nipecotate
- 1-(4-methoxyphenyl)-2-methylpiperazine
- N,N-dimethylethylenediamine
- 1-(3-aminopropyl)-2-pyrrolidinone

- isonipecotamide
ethyl 4-amino-1-piperidinecarboxylate
heptamethyleneimine
2-(aminomethyl)pyridine
5 1-(2-furoyl)-piperazine
bis(2-methoxyethyl)amine
N-(3-trifluoromethylphenyl)piperazine
3-acetamidopyrrolidine
1-ethoxycarbonylpiperazine
10 N-acetylenediamine
N-(2-aminoethyl)morpholine
5-aminoindazole
cyclopropylamine
4-(ethylaminomethyl)pyridine
15 cyclopentylamine
cycloheptylamine
3-(aminomethyl)pyridine
3-(trifluoromethyl)benzylamine
ethyl isonipecotate
20 thiomorpholine
thiophene-2-ethylamine
1-pyrrolidinepropanamine
N-(3-aminopropyl)imidazole

EXAMPLE 7

- 25 **Preparation of a combinatorial library of tetracyclic
benzimidazole derivative compounds**
(2-Morpholino-7-aminocarbonyl-ethyl-5H-benzimidazol
[1,2,d][1,4]benzodiazepin-6(7H)-one-10-carboxamides)

- Using the same experimental procedures as
30 described in Example 1, an additional combinatorial
library of 40 tetracyclic benzimidazole derivative
compounds were synthesized. This example describes 40
substituted amino variations used as building blocks for

the R⁴ position, the side chain of L-glutamine providing the R¹ position, 1-morpholino at the R⁷ position and hydrogen at the remaining R positions. The 40 amines used were as follows:

- 5 2-(aminomethyl)-1-ethylpyrrolidine
- 2-aminothiazole
- methyl 6-aminocaproate hydrochloride
- beta-alanine ethyl ester hydrochloride
- pyrrolidine
- 10 N-methylhomopiperazine
- 1-(4-fluorophenyl)piperazine
- 3-(methylthio)aniline
- 1-(2-pyridyl)piperazine
- 1-methyl-4-(methylamino)piperidine
- 15 2-(2-aminoethyl)pyridine
- 4-hydroxypiperidine
- 4-amino-2,2,6,6-tetramethylpiperidine
- ethyl nipecotate
- 1-(4-methoxyphenyl)-2-methylpiperazine
- 20 N,N-dimethylethylenediamine
- 1-(3-aminopropyl)-2-pyrrolidinone
- isonipecotamide
- ethyl 4-amino-1-piperidinecarboxylate
- heptamethyleneimine
- 25 2-(aminomethyl)pyridine
- 1-(2-furoyl)-piperazine
- bis(2-methoxyethyl)amine
- N-(3-trifluoromethylphenyl)piperazine
- 3-acetamidopyrrolidine
- 30 1-ethoxycarbonylpiperazine
- N-acetyleneethylenediamine
- N-(2-aminoethyl)morpholine
- 5-aminoindazole
- cyclopropylamine

- 4-(ethylaminomethyl)pyridine
cyclopentylamine
cycloheptylamine
3-(aminomethyl)pyridine
5 3-(trifluoromethyl)benzylamine
ethyl isonipecotate
thiomorpholine
thiophene-2-ethylamine
1-pyrrolidinepropanamine
10 N-(3-aminopropyl)imidazole

EXAMPLE 8

Preparation of a combinatorial library of tetracyclic benzimidazole derivative compounds

- (9- or 10-Substituted-2-morpholino-7-phenylmethyl
15 -5H-benzimidazol[1,2,d][1,4]benzodiazepin-6(7H)-one)

This example describes 7 variations at the 9- or 10-position of the tetracyclic benzimidazole derivative compounds, with 7 different 2-fluoronitrobenzene compounds providing the R³ or R⁴ positions, the side chain of phenylalanine providing the R¹ position, 1-morpholino at the R⁷ position and hydrogen at the remaining R positions.

Step 1:

Coupling N-protected amino acid to MBHA resin

- 25 1.0 g of MBHA resin (1.3 meq/g) was placed in a porous polypropylene packet (Tea-bag, 60mm x 60mm, 65 μ). The packet was washed with 5% DIEA/DCM (2 X 60 mL) in a 65 mL plastic bottle. DMF (40 mL), BOC-phenylalanine
30 (3.45g, 13 mmol), DIC (2.52g, 20 mmol), HOBt (1.75g, 13 mmol) were added sequentially. After shaking for 12 hours, the packet was washed alternatively with DMF (40 mL) and MeOH (40 mL) 3 cycles followed by DCM (40 mL) and MeOH (40 mL). The packet was dried in air for 1 h. The

packet was shaken with 55% TFA/DCM (40 mL) at room temperature for 40 minutes and washed with DCM (3 X 40 mL), 5% DIEA/DCM (2 X 40 mL) and MeOH (3 X 40 mL).

Step 2:

**5 N-Arylation with substituted or unsubstituted
2-fluoronitrobenzene**

The packet resulting from step 1 was heated in a solution of a 2-fluoronitrobenzoic acid (2.40g, 13 mmol)
10 and DIEA (1.64g, 13 mmol) in N-methylpyrrolidinone (40 mL) at 80° C for 24 hours. The packet was washed alternatively with DMF (40 mL) and MeOH (40 mL) for 3 cycles followed by washing with DCM (40 mL) and MeOH (2 X 40 mL). The packet was dried in air for 2 hours. The 7
15 2-fluoronitrobenzoic acids used were as follows:

4-fluoro-3-nitrobenzoic acid
5-bromo-2-fluoronitrobenzene
2-fluoronitrobenzene
2,5-difluoronitrobenzene
20 4-fluoro-3-nitrobenzotrifluoride
3-fluoro-4-nitrotoluene
4-chloro-2-fluoronitrobenzene

The resulting compounds were then prepared by following steps 4 to 6, as described in Example 1.

25 EXAMPLE 9

**Preparation of a combinatorial library of tetracyclic
benzimidazole derivative compounds
(9- or 10-Substituted-2-morpholino-7-aminocarbonylethyl
-5H-benzimidazol[1,2,d][1,4]benzodiazepin-6(7H)-one)**

30 Using the procedures described in Example 8,
this example describes 7 variations at the 9- or
10-position of the tetracyclic benzimidazole derivative

compounds, with 7 different 2-fluoronitrobenzene compounds providing the R³ or R⁴ positions, the side chain of glutamine providing the R¹ position, 1-morpholino at the R⁷ position and hydrogen at the remaining R positions.

5 The 7 2-fluoronitrobenzoic acids used were as follows:

- 4-fluoro-3-nitrobenzoic acid
- 5-bromo-2-fluoronitrobenzene
- 2-fluoronitrobenzene
- 2,5-difluoronitrobenzene
- 10 4-fluoro-3-nitrobenzotrifluoride
- 3-fluoro-4-nitrotoluene
- 4-chloro-2-fluoronitrobenzene

The resulting compounds were then prepared by following steps 4 to 6, as described in Example 1.

15

EXAMPLE 10

Preparation of a combinatorial library of 61,200 tetracyclic benzimidazole derivative compounds

Using the same experimental procedures described above, an additional combinatorial library of
20 61,200 (15 x 51 x 80) tetracyclic benzimidazole derivative compounds were synthesized. The side chain of any one of the 15 amino acids listed in Examples 4 and 5 provided the R¹ position. The 43 amines listed in Example 6 plus 3-(methylthio)propylamine and the 7 different
25 2-nitrofluorobenzene compounds listed in Examples 8 and 9 provided the 51 building blocks at the R⁴ or R³ position. The following 80 compounds provided the building blocks at the R⁷ position:

- cyclopropylamine
- 30 4-(2-aminoethyl)morpholine

- piperazine
2-methyl-1-(3-methylphenyl)piperazine
isonipecotamide
2-(2-aminoethyl)pyridine
5 N,N-dimethylethylenediamine
m-xylylenediamine
5-phenyl-1H-1,2,4-triazole-3-thiol
4-(3-aminopropyl)morpholine
tetrahydrofurfurylamine
10 1-(2,5-dimethylphenyl)piperazine
hexamethyleneimine
2-(2-methylaminoethyl)pyridine
N,N,N'-trimethylethylenediamine
p-xylylenediamine
15 6-mercaptonicotinic acid
N-acetylenediamine
 β -alanine-ethyl ester
1-(2,3-dimethylphenyl)piperazine
1-(2-pyridyl)piperazine
20 1-(3-aminopropyl)-2-pipecoline
ethylenediamine
cyclohexylamine
2-mercaptoimidazole
ethyl 1-piperazine carboxylate
25 3-methylthiopropylamine
1-(4-fluorophenyl)piperazine
1-benzyl-3-aminopyrrolidine
1-methyl-4-(methylamino)piperidine
1,3-diaminopropane
30 N-benzylmethylamine
4,6-dimethyl-2-mercaptopyrimidine
1-acetylpiperazine
2,3-dimethoxybenzylamine
N-(3,4-dichlorophenyl)piperazine
35 ethyl nipecotate

- 3-(aminomethyl)pyridine
N,N-diethyl-N'-methylethylenediamine
N-methylphenethylamine
2-mercapto-5-methyl-1,3,4-thiadiazole
5 2,2'-(ethylenedioxy)bis(ethylamine)
3-acetamidopyrrolidine
1-benzylpiperazine
ethyl isopecotate
N-(2-aminoethyl)piperidine
10 3-dimethylaminopropylamine
cycloheptylamine
3-mercapto-1,2,4-triazole
1-(ethoxycarbonylmethyl)piperazine
N,N-diethyl-2-butene-1,4-diamine
15 1-(4-nitrophenyl)piperazine
ethyl 4-amino-1-piperidinocarboxylate
4-amino-1-benzyl piperidine
N,N,N'-trimethyl-1,3-propanediamine
4-(trifluoromethyl)benzylamine
20 3-mercapto-4-methyl-1,2,4-triazole
2-ethoxyethylamine
tyramine
N-(3-trifluoromethylphenyl)piperazine
1,3,3-trimethyl-6-azabicyclo(3.2.1)octane
25 3,3'-bis(dimethylamino)-dipropylamine
butylamine
3-(trifluoromethyl)benzylamine
2-mercaptopyridine
1-(2-furoyl)piperazine
30 cyclooctylamine
4-piperazinoacetophenone
1-(4-methylphenyl)-2-methylpiperazine
2-fluorophenethylamine
3-fluorophenethylamine
35 4-fluorobenzylamine

hydrofluoric acid
morpholine
thiomorpholine
1-(5-chloro-ortho-tolyl)-piperazine
5 2-(aminoethyl)-1-ethylpyrrolidine
4-amino-2,2,6,6-tetramethylpiperidine
diethylamine
3,3,5-trimethylcyclohexylamine

10

EXAMPLE 11**Melanocortin Receptor Assay**

This example describes methods for assaying binding to MC receptors.

All cell culture media and reagents were
15 obtained from GibcoBRL (Gaithersburg MD), except for
COSMIC CALF SERUM (HyClone; Logan UT). HEK 293 cell
lines were transfected with the human MC receptors hMCR-
1, hMCR-3, and hMCR-4 (Gantz et al., Biochem. Biophys.
Res. Comm. 200:1214-1220 (1994); Gantz et al., J. Biol.
20 Chem. 268:8246-8250 (1993); Gantz et al. J. Biol. Chem.
268:15174-15179 (1993); Haskell-Leuvano et al., Biochem.
Biophys. Res. Comm. 204:1137-1142 (1994); each of which
is incorporated herein by reference). Vectors for
construction of an hMCR-5 expressing cell line were
25 obtained, and a line of HEK 293 cells expressing hMCR-5
was constructed (Gantz, *supra*, 1994). hMCR-5 has been
described previously (Franberg et al., Biochem. Biophys.
Res. Commun. 236:489-492 (1997); Chowdhary et al.,
Cytogenet. Cell Genet. 68:1-2 (1995); Chowdhary et al.,
30 Cytogenet. Cell Genet. 68:79-81 (1995), each of which is
incorporated herein by reference). HEK 293 cells were
maintained in DMEM, 25 mM HEPES, 2 mM glutamine,
non-essential amino acids, vitamins, sodium pyruvate,

10% COSMIC CALF SERUM, 100 units/ml penicillin, 100 µg/ml streptomycin and 0.2 mg/ml G418 to maintain selection.

Before assaying, cells were washed once with phosphate buffered saline ("PBS"; without Ca^{2+} and Mg^{2+}),
5 and stripped from the flasks using 0.25% trypsin and 0.5 mM EDTA. Cells were suspended in PBS, 10% COSMIC CALF SERUM and 1 mM CaCl_2 . Cell suspensions were prepared at a density of 2×10^4 cells/ml for HEK 293 cells expressing hMCR-3, hMCR-4 or hMCR-5, and 1×10^5 cells/ml
10 for HEK 293 cells expressing hMCR-1. Suspensions were placed in a water bath and allowed to warm to 37°C for 1 hr.

Binding assays were performed in a total volume of 250 µl for HEK 293 cells. Control and test compounds
15 were dissolved in distilled water. ^{125}I -HP 467 (50,000 dpm) (2000 Ci/mmol) (custom labeled by Amersham; Arlington Heights IL) was prepared in 50 mM Tris, pH 7.4, 2 mg/ml BSA, 10 mM CaCl_2 , 5 mM MgCl_2 , 2 mM EDTA and added to each tube. To each tube was added 4×10^3 HEK 293 cells
20 expressing hMCR-3, hMCR-4 or hMCR-5, or 2×10^4 cells expressing hMCR-1. Assays were incubated for 2.5 hr at 37°C.

GF/B filter plates were prepared by soaking for at least one hour in 5 mg/ml BSA and 10 mM CaCl_2 . Assays
25 were filtered using a Brandel 96-well cell harvester (Brandel Inc.; Gaithersburg, MD). The filters were washed four times with cold 50 mM Tris, pH 7.4, the filter plates were dehydrated for 2 hr and 35 µl of MICROSCINT was added to each well. Filter plates were
30 counted using a Packard Topcount (Packard Instrument Co.) and data analyzed using GraphPad PRISM v2.0 (GraphPad

Software Inc.; San Diego CA) and Microsoft EXCEL v5.0a (Microsoft Corp.; Redmond WA).

To assay tetracyclic benzimidazole derivative compounds, binding assays were performed in duplicate in a 96 well format. HP 467 was prepared in 50 mM Tris, pH 7.4, and ^{125}I -HP 467 was diluted to give 100,000 dpm per 50 μl . A tetracyclic benzimidazole derivative compound, synthesized as described in Examples 1 to 9, was added to the well in 25 μl aliquots. A 25 μl aliquot of ^{125}I -HP 467 was added to each well. A 0.2 ml aliquot of suspended cells was added to each well to give the cell numbers indicate above, and the cells were incubated at 37°C for 2.5 hr. Cells were harvested on GF/B filter plates as described above and counted.

15

EXAMPLE 12

Anti-microbial Screen

Streptococcus pyogenes (ATCC# 97-03 14289) were grown in Todd Hewitt Broth (THB) (Difco Laboratories #0492-17-6) overnight until they reached an optical density of (OD = 0.636 @ 570 nm) by reading 0.1 ml in a 96 well microtiter plate in a Molecular Devices Thermomax. This preparation was kept frozen as stocks in 30% v/v glycerol in 1.5 ml aliquots at -70 C° until used. Prior to screening, 1.5 ml aliquots were thawed and diluted into 50 ml THB. 200 μl of this dilution was added to 92 wells of microtiter plate. To three wells THB (200 μl) was added to serve as a blank and a sterility control. Test compounds in DMSO and appropriate concentrations of DMSO were added to Growth/Solvent Controls at 0 time. Plates were read at 0 time at 570 nm in the Molecular Devices plate reader to

obtain compounds correction factors for insoluble or colored compounds. Plates were read again at 4 hrs.

Compounds were assayed at a concentration of 170 µg/ml. Percent inhibition for each compound was
5 calculated using the following formulae:

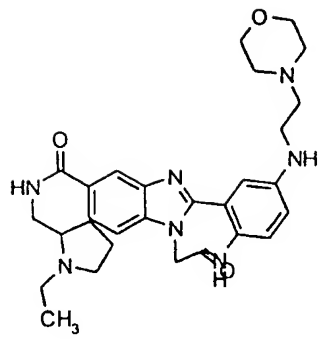
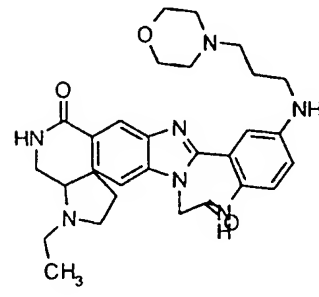
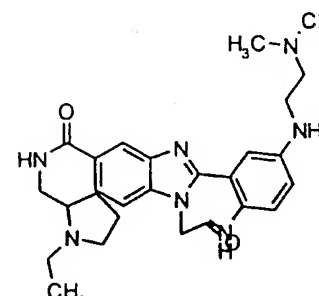
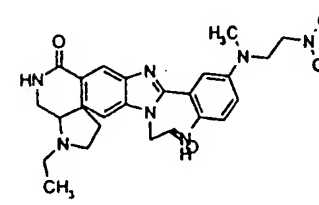
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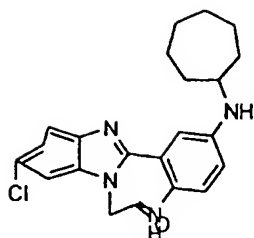
(O.D. 0 hr - Blank 0 hr) - (Solvent Control 0 hr - Blank
0 hr)

10 % Inhibition =

100 - (O.D. test compound 4 hr - Blank 4 hr - color
correct) divided by (O.D. growth/solvent control 4 hr -
Blank 4 hr)

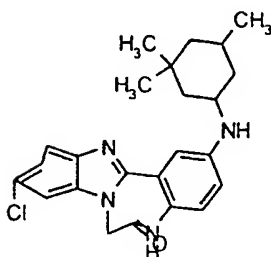
Percent inhibition of tetracyclic benzimidazole
15 compounds of the invention are provided in the table
below:

	Sample ID	% Inhibition
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	6000#00010	95.74806837
	6000#00007	95.22360103
	6000#00015	96.27253571



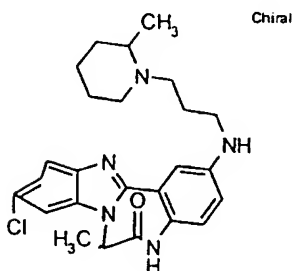
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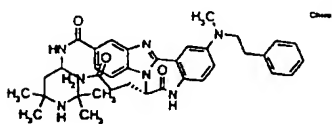
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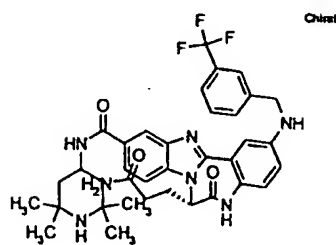
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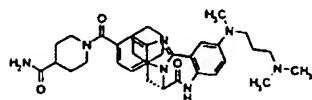
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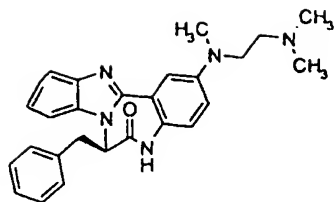
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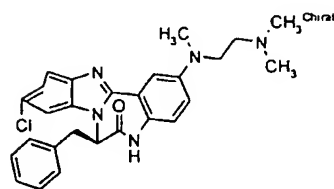
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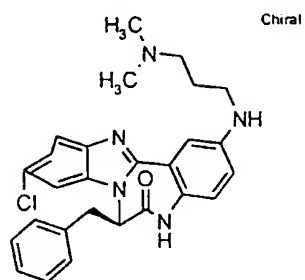
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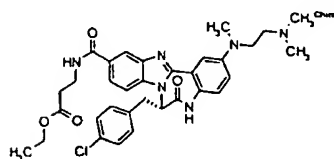
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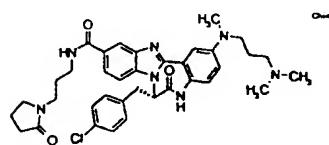
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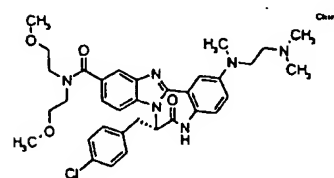
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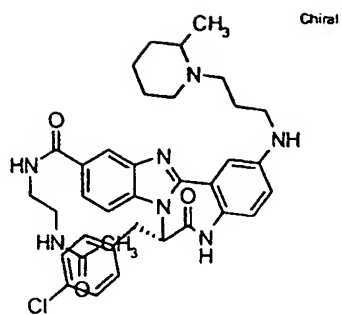
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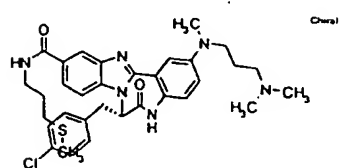
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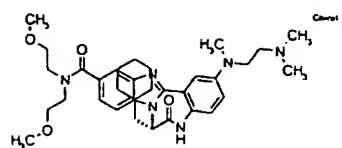
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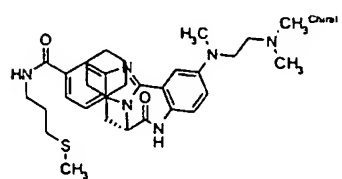
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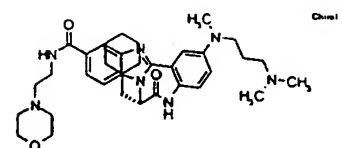
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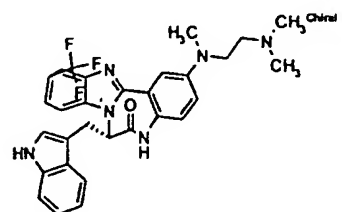
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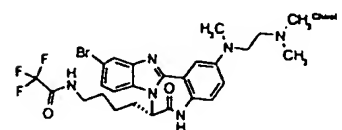
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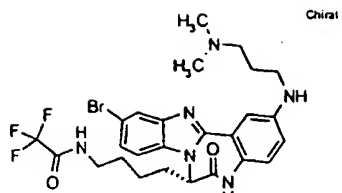
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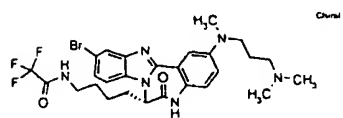


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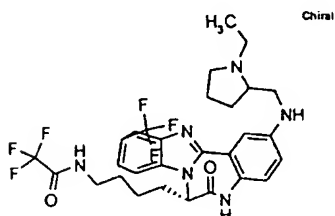
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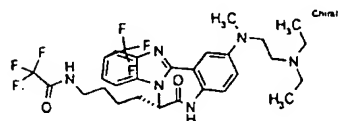
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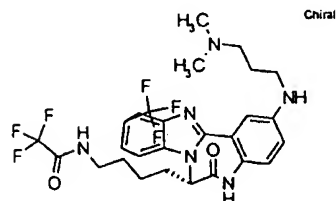
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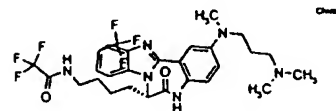
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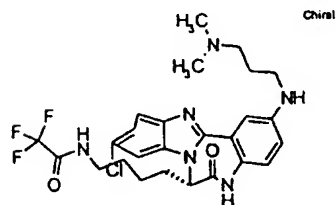
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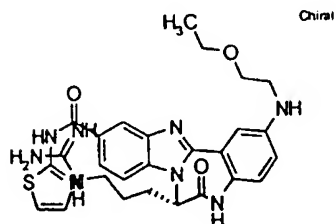
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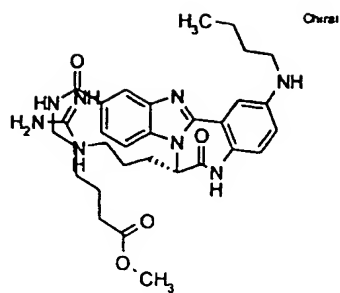
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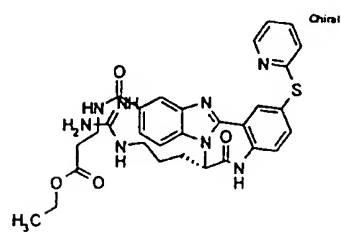
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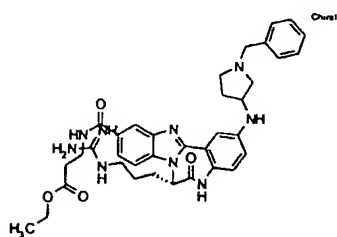
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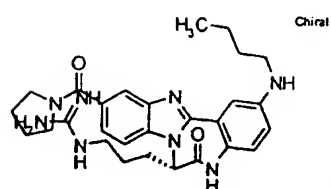
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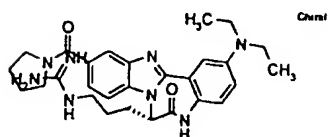
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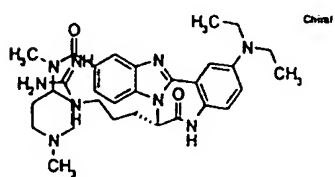
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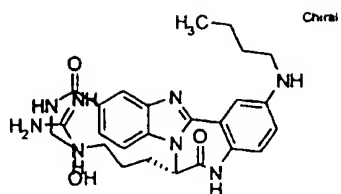
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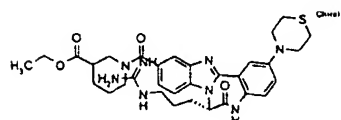
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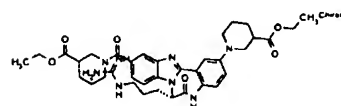
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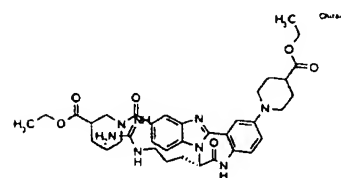
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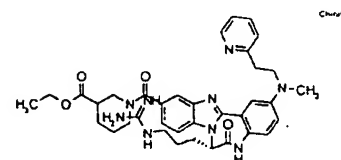
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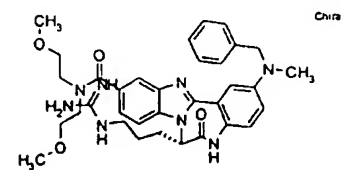
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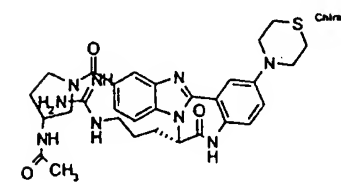
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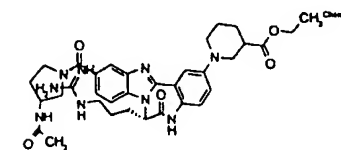
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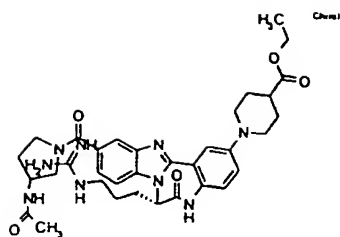
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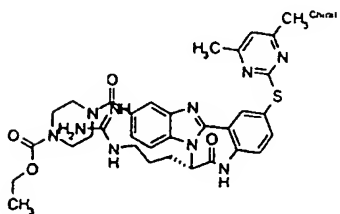
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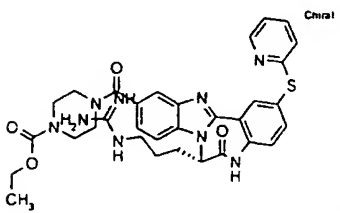
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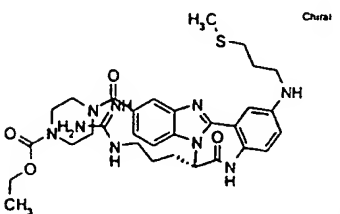
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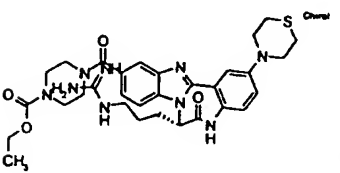
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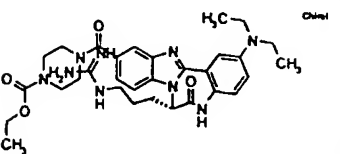
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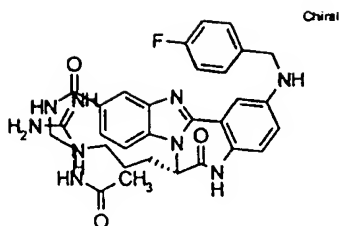
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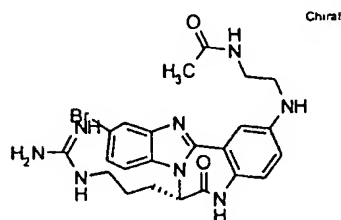
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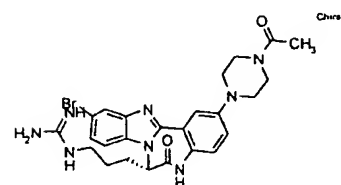
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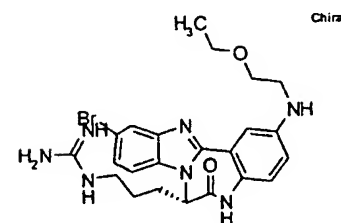
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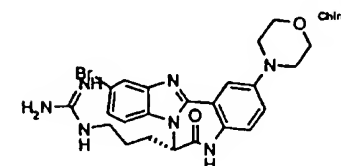
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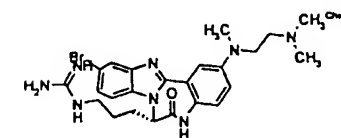
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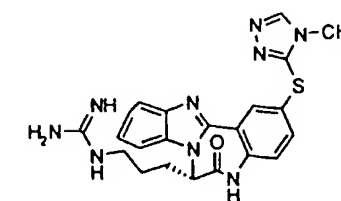
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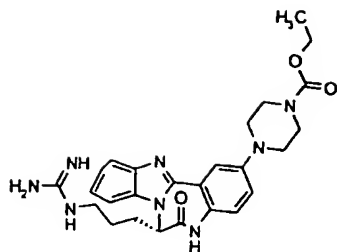
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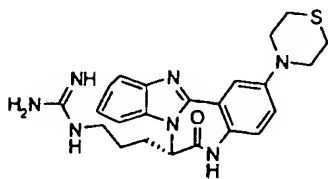
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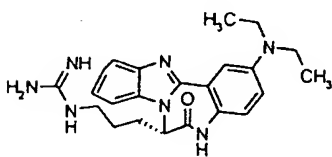
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EXAMPLE 13**Penile erection due to administration of a tetracyclic benzimidazole compound**

Adult male rats are housed 2-3 per cage and are
5 acclimated to the standard vivarium light cycle (12 hr.
light, 12 hr. dark), rat chow and water for a least a
week prior to testing. All experiments are performed
between 9 a.m. and noon and rats are placed in
cylindrical, clear plexiglass chambers during the 60
10 minute observation period. Mirrors are positioned below
and to the sides of the chambers, to improve viewing.

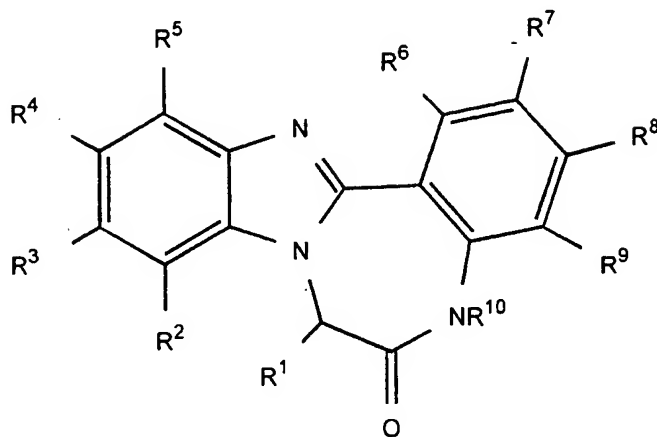
Observations begin 10 minutes after an
unstraperitoneal injection of either saline or compound.
An observer counts the number of grooming motions,
15 stretches, yawns and penile erections (spontaneously
occurring, not elicited by genital grooming) and records
them every 5 minutes, for a total of 60 minutes. The
observer is unaware of the treatment and animals are
tested once, with n=6 in each group. Values in the
20 figures represent the group mean and standard error of
the mean. HP 228 can be used as a positive control for
penile erections. Significant differences between groups
are determined by an overall analysis of variance and the
Student Neunmann-Keuls post hoc test can be used to
25 identify individual differences between groups
($p \leq 0.05$).

Although the invention has been described with
reference to the examples provided above, it should be

understood that various modifications can be made by those skilled in the art without departing from the invention. Accordingly, the invention is set out in the following claims.

WE CLAIM:

1. A combinatorial library of two or more compounds of the formula:



5 wherein:

- R^i is selected from the group consisting of a hydrogen atom, C_1 to C_{12} alkyl, C_1 to C_{12} substituted alkyl, phenyl, substituted phenyl, C_7 to C_{18} phenylalkyl, C_7 to C_{18} substituted phenylalkyl, C_1 to C_{12} heterocycloalkyl, C_1 to C_{12} substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, cyano, C_1 to C_{12} acyl, C_1 to C_{12} substituted acyl, C_1 to C_{12} alkoxycarbonyl, C_1 to C_{12} substituted alkoxycarbonyl, C_1 to C_{12} alkylaminocarbonyl, C_1 to C_{12} substituted alkylaminocarbonyl, phenylaminocarbonyl, substituted phenylaminocarbonyl, C_1 to C_{10} alkylthio, C_1 to C_{10} substituted alkylthio, C_1 to C_{10} alkylsulfonyl, C_1 to C_{10} substituted alkylsulfonyl, C_1 to C_{10} alkylsulfoxide, C_1 to C_{10} substituted alkylsulfoxide, phenylthio, substituted phenylthio, phenylsulfoxide, substituted phenylsulfoxide, phenylsulfonyl, substituted phenylsulfonyl, heterocycle, substituted heterocycle, cyclic C_2 to C_7 alkylene,

substituted cyclic C₂ to C₇ alkylene, cyclic C₂ to C₇
heteroalkylene, substituted cyclic C₂ to C₇
heteroalkylene, naphthyl, substituted naphthyl, C₅ to C₇
cycloalkyl, C₅ to C₇ substituted cycloalkyl, C₅ to C₇
5 cycloalkenyl and C₅ to C₇ substituted cycloalkenyl;

R², R³, R⁴, R⁵, R⁶, R⁷, R⁸ and R⁹ are, independently,
selected from the group consisting of a hydrogen atom,
halo, hydroxy, protected hydroxy, cyano, C₁ to C₁₂ alkyl,
C₂ to C₁₂ alkenyl, C₂ to C₁₂ alkynyl, C₁ to C₁₂ substituted
10 alkyl, C₂ to C₁₂ substituted alkenyl, C₂ to C₁₂ substituted
alkynyl, C₁ to C₁₂ alkoxy, C₁ to C₁₂ substituted alkoxy, C₁
to C₁₂ acyloxy, C₁ to C₁₂ acyl, C₃ to C₇ cycloalkyl, C₃ to C₇
substituted cycloalkyl, C₅ to C₇ cycloalkenyl, C₅ to C₇
substituted cycloalkenyl, heterocyclic ring, substituted
15 heterocyclic ring, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈
substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁ to
C₁₂ substituted heterocycloalkyl, phenyl, substituted
phenyl, naphthyl, substituted naphthyl, cyclic C₂ to C₇
alkylene, substituted cyclic C₂ to C₇ alkylene, cyclic C₂
20 to C₇ heteroalkylene, substituted cyclic C₂ to C₇
heteroalkylene, carboxy, protected carboxy,
hydroxymethyl, protected hydroxymethyl, amino, protected
amino, (monosubstituted)amino, protected
(monosubstituted)amino, (disubstituted)amino, C₁ to C₁₀
25 alkylamino, C₁ to C₁₀ alkyl protected amino, C₁ to C₁₀ alkyl
(monosubstituted)amino, C₁ to C₁₀ alkyl, protected
(monosubstituted)amino, C₁ to C₁₀
alkyl(disubstituted)amino, C₁ to C₁₀ substituted
alkylamino, C₁ to C₁₀ substituted alkyl protected amino, C₁
30 to C₁₀ substituted alkyl (monosubstituted)amino, C₁ to C₁₀
substituted alkyl protected (monosubstituted)amino, C₁ to
C₁₀ substituted alkyl(disubstituted)amino, carboxamide,
protected carboxamide, C₁ to C₁₀ alkylthio, C₁ to C₁₀
substituted alkylthio, C₁ to C₁₀ alkylsulfonyl, C₁ to C₁₀

substituted alkylsulfonyl, C₁ to C₁₀ alkylsulfoxide, C₁ to C₁₀ substituted alkylsulfoxide, phenylthio, substituted phenylthio, phenylsulfoxide, substituted phenylsulfoxide, phenylsulfonyl, substituted phenylsulfonyl and and the
5 group consisting of (i) the formula -C(O)NR¹¹R¹², (ii) the formula -C(O)R¹¹, (iii) the formula -NR¹¹R¹², (iv) the formula -SR¹¹, (v) the formula -OR¹¹ and (vi) the formula -C(O)OR¹¹, wherein R¹¹ and R¹² are, independently, selected from the group consisting of a hydrogen atom, C₁ to C₁₂
10 alkyl, C₁ to C₁₂ substituted alkyl, C₂ to C₁₂ alkenyl, C₂ to C₁₂ substituted alkenyl, phenyl, substituted phenyl, naphthyl, substituted naphthyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈ substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁ to C₁₂ substituted heterocycloalkyl, heteroaryl,
15 substituted heteroaryl, heterocycle, substituted heterocycle, C₁ to C₁₂ acyl, C₁ to C₁₂ substituted acyl, phenylsulfonyl, substituted phenylsulfonyl, C₁ to C₁₀ alkylsulfonyl, C₁ to C₁₀ substituted alkylsulfonyl, C₁ to C₁₂ alkylaminocarbonyl, C₁ to C₁₂ substituted
20 alkylaminocarbonyl, phenylaminocarbonyl, and substituted phenylaminocarbonyl; and

R¹⁰ is selected from the group consisting of a hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, C₂ to C₁₂ alkenyl, C₂ to C₁₂ substituted alkenyl, C₇ to C₁₈
25 phenylalkyl, C₇ to C₁₈ substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl and C₁ to C₁₂ substituted heterocycloalkyl; or

a pharmaceutically acceptable salt of a compound thereof.

2. The combinatorial library of claim 1, wherein

R^i is selected from the group consisting of a hydrogen atom, C_1 to C_{12} alkyl, C_1 to C_{12} substituted alkyl, phenyl, substituted phenyl, C_7 to C_{18} phenylalkyl, C_7 to C_{18} substituted phenylalkyl, C_1 to C_{12} heterocycloalkyl, C_1 to C_{12} substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, C_1 to C_{10} alkylthio, C_1 to C_{10} substituted alkylthio, heterocycle and substituted heterocycle.

3. The combinatorial library of claim 1, wherein

10 R^2 , R^3 , R^4 and R^5 are, independently, selected from the group consisting of a hydrogen atom, halo, hydroxy, protected hydroxy, cyano, C_1 to C_{12} alkyl, C_1 to C_{12} substituted alkyl, C_1 to C_{12} alkoxy, C_1 to C_{12} substituted alkoxy, carboxy, protected carboxy, C_1 to C_{10} alkylthio, C_1 to C_{10} substituted alkylthio, the formula $-C(O)NR^{11}R^{12}$ and
15 the formula $-C(O)R^{11}$, wherein R^{11} and R^{12} are, independently, selected from the group consisting of a hydrogen atom, C_1 to C_{12} alkyl, C_1 to C_{12} substituted alkyl, phenyl, substituted phenyl, C_7 to C_{18} phenylalkyl, C_7 to C_{18} substituted phenylalkyl, C_1 to C_{12} heterocycloalkyl, C_1 to C_{12} substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, heterocycle and substituted heterocycle.
20

4. The combinatorial library of claim 1, wherein

R^2 , R^3 , and R^5 are each a hydrogen atom, and R^4 is the
25 formula $-C(O)NR^{11}R^{12}$ or the formula $-C(O)R^{11}$, wherein R^{11} and R^{12} are, independently, selected from the group consisting of a hydrogen atom, C_1 to C_{12} alkyl, C_1 to C_{12} substituted alkyl, phenyl, substituted phenyl, C_7 to C_{18} phenylalkyl, C_7 to C_{18} substituted phenylalkyl, C_1 to C_{12} heterocycloalkyl, C_1 to C_{12} substituted heterocycloalkyl,
30

heteroaryl, substituted heteroaryl, heterocycle and substituted heterocycle.

5. The combinatorial library of claim 1, wherein

R⁶, R⁷, R⁸ and R⁹ are, independently, selected from the
5 group consisting of a hydrogen atom, halo, heterocycle, substituted heterocycle, the formula -NR¹¹R¹² and the formula -SR¹¹, wherein R¹¹ and R¹² are, independently, selected from the group consisting of a hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, C₂ to C₁₂ alkenyl,
10 C₂ to C₁₂ substituted alkenyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈ substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁ to C₁₂ substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, heterocycle and substituted heterocycle.

15 6. The combinatorial library of claim 1, wherein

R⁶, R⁸ and R⁹ are each a hydrogen atom, and R⁷ is selected from the group consisting of halo, heterocycle, substituted heterocycle, the formula -NR¹¹R¹² and the formula -SR¹¹, wherein R¹¹ and R¹² are, independently,
20 selected from the group consisting of a hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, C₂ to C₁₂ alkenyl, C₂ to C₁₂ substituted alkenyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈ substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁ to C₁₂ substituted heterocycloalkyl, heteroaryl,
25 substituted heteroaryl, heterocycle and substituted heterocycle.

7. The combinatorial library of claim 1, wherein R¹⁰ is a hydrogen atom.

8. The combinatorial library of claim 1, wherein

R^1 is selected from the group consisting of a hydrogen atom, C_1 to C_{12} alkyl, C_1 to C_{12} substituted alkyl, phenyl, substituted phenyl, C_7 to C_{13} phenylalkyl, C_7 to C_{18} substituted phenylalkyl, C_1 to C_{12} heterocycloalkyl, C_1 to C_{12} substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, C_1 to C_{10} alkylthio, C_1 to C_{10} substituted alkylthio, heterocycle and substituted heterocycle;

R^2 , R^3 , R^4 and R^5 are, independently, selected from the group consisting of a hydrogen atom, halo, hydroxy, protected hydroxy, cyano, C_1 to C_{12} alkyl, C_1 to C_{12} substituted alkyl, C_1 to C_{12} alkoxy, C_1 to C_{12} substituted alkoxy, carboxy, protected carboxy, C_1 to C_{10} alkylthio, C_1 to C_{10} substituted alkylthio, the formula $-C(O)NR^{11}R^{12}$ and the formula $-C(O)R^{11}$, wherein are, independently, selected from the group consisting of a hydrogen atom, C_1 to C_{12} alkyl, C_1 to C_{12} substituted alkyl, phenyl, substituted phenyl, C_7 to C_{13} phenylalkyl, C_7 to C_{18} substituted phenylalkyl, C_1 to C_{12} heterocycloalkyl, C_1 to C_{12} substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, heterocycle and substituted heterocycle;

R^6 , R^8 and R^9 are each a hydrogen atom, and R^7 is selected from the group consisting of halo, heterocycle, substituted heterocycle, the formula $-NR^{11}R^{12}$ and the formula $-SR^{11}$, wherein R^{11} and R^{12} are, independently, selected from the group consisting of a hydrogen atom, C_1 to C_{12} alkyl, C_1 to C_{12} substituted alkyl, C_2 to C_{12} alkenyl, C_2 to C_{12} substituted alkenyl, C_7 to C_{13} phenylalkyl, C_7 to C_{18} substituted phenylalkyl, C_1 to C_{12} heterocycloalkyl, C_1 to C_{12} substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, heterocycle and substituted heterocycle; and

R¹⁰ is a hydrogen atom.

9. The combinatorial library of claim 1, wherein

R¹ is selected from the group consisting of a hydrogen atom, methyl, 2-propyl, 2-butyl, aminocarbonylethyl,
5 2-methylmercaptoethyl, phenyl, benzyl, cyclohexylmethyl, 4-methoxybenzyl, 4-chlorobenzyl, 3-indolylmethyl, 4-(trifluoroacetyl)aminobutyl and 3-guanidinopropyl;

R², R³, R⁵, R⁶, R⁸, R⁹ and R¹⁰ are each a hydrogen atom;

R⁴ is the formula -C(O)NR¹¹R¹², wherein R¹¹ and R¹² join the
10 nitrogen atom in the depicted formula to form a substituent selected from the group consisting of 1-pyrrolidino, 4-methyl-1-homopiperazino, 4-(4-fluorophenyl)-1-piperazino, 4-(2-hydroxyethoxyethyl)-1-piperazino,
15 4-(2-pyridyl)-1-piperazino, 4-hydroxy-1-piperidino, 4-amino-2,2,6,6-tetramethyl-1-piperidino, 3-ethoxycarbonyl-1-piperidino, 4-(4-methoxyphenyl)-3-methyl-1-piperazino, 4-aminocarbonyl-1-piperidino, heptamethyleneimino,
20 4-(2-furoyl)-1-piperazino, 4-(3-trifluoromethylphenyl)-1-piperazino, 3-acetamido-1-pyrrolidino, 4-ethoxycarbonyl-1-piperazino, 4-ethoxycarbonyl-1-piperidino and 4-thiomorpholino, or R¹¹ and R¹² are, independently, selected from the group
25 consisting of a hydrogen atom, (1-ethyl-2-pyrrolidinyl)methyl, 2-thiazolyl, 5-methoxycarbonylpentyl, 2-ethoxycarbonylethyl, 3-(methylthio)phenyl, N-methyl-(1-methyl-4-piperidino), 2-(pyridin-2-yl)ethyl, 2-hydroxyethyl,
30 4-(trifluoromethyl)benzyl, N,N-dimethylaminoethyl, 3-(2-oxo-1-pyrrolidino)propyl,

1-ethoxycarbonyl-4-piperidino, pyridin-2-ylmethyl,
bis(2-methoxyethyl), 2-acetylaminoethyl,
3-(methylthio)propyl, 2-(1-morpholino)ethyl, 5-indazolyl,
cyclopropyl, N-ethyl-(pyridin-4-ylmethyl), cyclopentyl,
5 cycloheptyl, pyridin-3-ylmethyl,
4-(trifluoromethyl)benzyl, 2-(thien-2-yl)ethyl,
3-(N-pyrrolidino)propyl and 3-(1-imidazolyl)propyl;

R⁷ is selected from the group consisting of
cyclopropylamino, 2-(1-morpholino)ethylamino, piperazino,
10 2-methyl-4-(3-methylphenyl)-1-piperazino,
4-aminocarbonylpiperidino, 2-(pyridin-2-yl)ethylamino,
2-(N,N-dimethylamino)ethylamino,
3-(aminomethyl)benzylamino,
(5-phenyl-1H-1,2,4-triazol-3-yl)thio,
15 3-(4-morpholino)propylamino, tetrahydrofurfurylamino,
4-(2,5-dimethylphenyl)-1-piperazino, hexamethyleneimino,
N-methyl-2-(pyridin-2-yl)ethylamino,
2-(dimethylamino)ethylamino, 4-(aminomethyl)benzylamino,
(3-carboxypyridin-6-yl)thio, 2-acetylaminoethylamino,
20 2-(ethoxycarbonyl)ethylamino,
4-(2,3-dimethylphenyl)-1-piperazino,
4-(2-pyridyl)-1-piperazino, 3-(2-pipecolino)propylamino,
2-aminoethylamino, cyclohexylamino, imidazol-2-ylthio,
4-ethoxycarbonyl-1-piperazino, 3-methylthiopropylamino,
25 4-(4-fluorophenyl)piperazino,
1-benzyl-3-pyrrolidinoamino, N-methyl-4-piperidylamino,
3-aminopropylamino, N-benzylmethylamino,
(3,5-dimethyl-2,6-pyrimidin-2-yl)thio,
4-acetyl-1-piperazino, 2,3-dimethoxybenzylamino,
30 4-(3,4-dichlorophenyl)-1-piperazino,
3-ethoxycarbonyl-1-piperidino, pyridin-3-ylmethylamino,
N-methyl-2-(diethylamino)ethylamino,
N-methylphenethylamino,
(5-methyl-1,3,4-thiadiazol-2-yl)thio,

- 8-amino-3,6-dioxaoctylamino, 3-acetamido-1-pyrrolidino,
4-benzyl-1-piperazino, 4-ethoxycarbonyl-1-piperazino,
2-piperadinoethylamino, 3-dimethylaminopropylamino,
cycloheptylamino, (1H-1,2,4-triazol-3-yl)thio,
5 4-ethoxycarbonylmethyl-1-piperazino,
4-(diethylamino)-2-butenylamino,
4-(4-nitrophenyl)-1-piperazino,
1-ethoxycarbonyl-4-piperidylamino,
1-benzyl-4-piperidylamino,
10 N-methyl-3-(dimethylamino)propylamino,
4-(trifluoromethyl)benzylamino,
(4-methyl-1,2,4-triazol-3-yl)thio, 2-ethoxyethylamino,
tyramino, 4-(3-trifluoromethylphenyl)-1-piperazino,
1,3,3-trimethyl-6-aza-6-bicyclo(3,2,1)octyl,
15 3,3'-bis(dimethylamino)dipropylamino, butylamino,
3-(trifluoromethyl)benzylamino, pyridin-2-ylthio,
4-(2-furoyl)-1-piperazino, cyclooctylamino,
4-(4-acetylphenyl)-1-piperazino,
4-(4-methylphenyl)-3-methyl-1-piperazino,
20 2-fluorophenethylamino, 3-fluorophenethylamino,
4-fluorobenzylamino, fluoro, morpholino, thiomorpholino,
4-(5-chloro-2-methylphenyl)-1-piperazino,
(1-ethyl-2-pyrrolidino)methylamino,
2,2,6,6-tetramethyl-4-piperidylamino, diethylamino and
25 3,3,5-trimethylcyclohexylamino.

10. The combinatorial library of claim 1, wherein

- R¹ is selected from the group consisting of a hydrogen
atom, methyl, 2-propyl, 2-butyl, aminocarbonyl ethyl,
2-methylmercaptoethyl, phenyl, benzyl, cyclohexylmethyl,
30 4-methoxybenzyl, 4-chlorobenzyl, 3-indolylmethyl,
4-(trifluoroacetyl)aminobutyl and 3-guanidinopropyl;

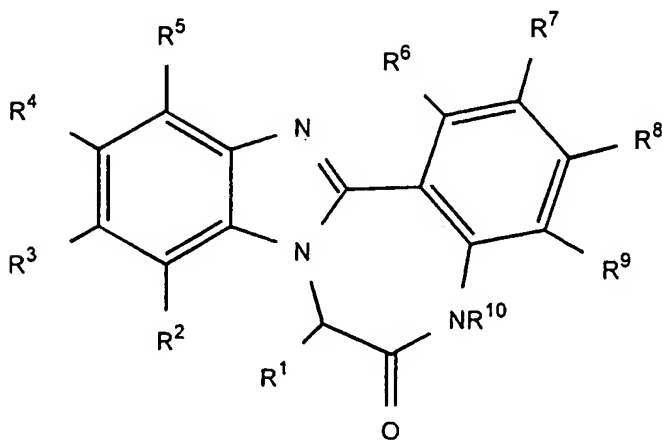
R^2 , R^3 , R^4 and R^5 are, independently selected from the group consisting of a hydrogen atom, methyl, carboxy, bromo, fluoro, chloro and trifluoromethyl;

R^6 , R^8 , R^9 and R^{10} are each a hydrogen atom; and

- 5 R^7 is selected from the group consisting of
cyclopropylamino, 2-(1-morpholino)ethylamino, piperazino,
2-methyl-4-(3-methylphenyl)-1-piperazino,
4-aminocarbonylpiperidino, 2-(pyridin-2-yl)ethylamino,
2-(N,N-dimethylamino)ethylamino,
10 3-(aminomethyl)benzylamino,
(5-phenyl-1H-1,2,4-triazol-3-yl)thio,
3-(4-morpholino)propylamino, tetrahydrofurfurylamino,
4-(2,5-dimethylphenyl)-1-piperazino, hexamethyleneimino,
N-methyl-2-(pyridin-2-yl)ethylamino,
15 2-(dimethylamino)ethylamino, 4-(aminomethyl)benzylamino,
(3-carboxypyridin-6-yl)thio, 2-acetylaminomethylamino,
2-(ethoxycarbonyl)ethylamino,
4-(2,3-dimethylphenyl)-1-piperazino,
4-(2-pyridyl)-1-piperazino, 3-(2-pipecolino)propylamino,
20 2-aminoethylamino, cyclohexylamino, imidazol-2-ylthio,
4-ethoxycarbonyl-1-piperazino, 3-methylthiopropylamino,
4-(4-fluorophenyl)piperazino,
1-benzyl-3-pyrrolidinamino, N-methyl-4-piperidylamino,
3-aminopropylamino, N-benzylmethylamino,
25 (3,5-dimethyl-2,6-pyrimidin-2-yl)thio,
4-acetyl-1-piperazino, 2,3-dimethoxybenzylamino,
4-(3,4-dichlorophenyl)-1-piperazino,
3-ethoxycarbonyl-1-piperidino, pyridin-3-ylmethylamino,
N-methyl-2-(diethylamino)ethylamino,
30 N-methylphenethylamino,
(5-methyl-1,3,4-thiadiazol-2-yl)thio,
8-amino-3,6-dioxaoctylamino, 3-acetamido-1-pyrrolidino,
4-benzyl-1-piperazino, 4-ethoxycarbonyl-1-piperazino,

- 2-piperadinoethylamino, 3-dimethylaminopropylamino,
 cycloheptylamino, (1H-1,2,4-triazol-3-yl)thio,
 4-ethoxycarbonylmethyl-1-piperazino,
 4-(diethylamino)-2-butenylamino,
 5 4-(4-nitrophenyl)-1-piperazino,
 1-ethoxycarbonyl-4-piperidylamino,
 1-benzyl-4-piperidylamino,
 N-methyl-3-(dimethylamino)propylamino,
 4-(trifluoromethyl)benzylamino,
 10 (4-methyl-1,2,4-triazol-3-yl)thio, 2-ethoxyethylamino,
 tyramino, 4-(3-trifluoromethylphenyl)-1-piperazino,
 1,3,3-trimethyl-6-aza-6-bicyclo(3,2,1)octyl,
 3,3'-bis(dimethylamino)dipropylamino, butylamino,
 3-(trifluoromethyl)benzylamino, pyridin-2-ylthio,
 15 4-(2-furoyl)-1-piperazino, cyclooctylamino,
 4-(4-acetylphenyl)-1-piperazino,
 4-(4-methylphenyl)-3-methyl-1-piperazino,
 2-fluorophenethylamino, 3-fluorophenethylamino,
 4-fluorobenzylamino, fluoro, morpholino, thiomorpholino,
 20 4-(5-chloro-2-methylphenyl)-1-piperazino,
 (1-ethyl-2-pyrrolidino)methylamino,
 2,2,6,6-tetramethyl-4-piperidylamino, diethylamino and
 3,3,5-trimethylcyclohexylamino.

11. A single compound of the formula:



wherein:

- R^1 is selected from the group consisting of a hydrogen atom, C_1 to C_{12} alkyl, C_1 to C_{12} substituted alkyl, phenyl, substituted phenyl, C_7 to C_{18} phenylalkyl, C_7 to C_{18} substituted phenylalkyl, C_1 to C_{12} heterocycloalkyl, C_1 to C_{12} substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, cyano, C_1 to C_{12} acyl, C_1 to C_{12} substituted acyl, C_1 to C_{12} alkoxycarbonyl, C_1 to C_{12} substituted alkoxycarbonyl, C_1 to C_{12} alkylaminocarbonyl, C_1 to C_{12} substituted alkylaminocarbonyl, phenylaminocarbonyl, substituted phenylaminocarbonyl, C_1 to C_{10} alkylthio, C_1 to C_{10} substituted alkylthio, C_1 to C_{10} alkylsulfonyl, C_1 to C_{10} substituted alkylsulfonyl, C_1 to C_{10} alkylsulfoxide, C_1 to C_{10} substituted alkylsulfoxide, phenylthio, substituted phenylthio, phenylsulfoxide, substituted phenylsulfoxide, phenylsulfonyl, substituted phenylsulfonyl, heterocycle, substituted heterocycle, cyclic C_2 to C_7 alkylene, substituted cyclic C_2 to C_7 alkylene, cyclic C_2 to C_7 heteroalkylene, substituted cyclic C_2 to C_7 heteroalkylene, naphthyl, substituted naphthyl, C_5 to C_7 cycloalkyl, C_5 to C_7 substituted cycloalkyl, C_5 to C_7 cycloalkenyl and C_5 to C_7 substituted cycloalkenyl;

- R^2 , R^3 , R^4 , R^5 , R^6 , R^8 and R^9 are, independently, selected from the group consisting of a hydrogen atom, halo, hydroxy, protected hydroxy, cyano, C_1 to C_{12} alkyl, C_2 to C_{12} alkenyl, C_2 to C_{12} alkynyl, C_1 to C_{12} substituted alkyl, C_2 to C_{12} substituted alkenyl, C_2 to C_{12} substituted alkynyl, C_1 to C_{12} alkoxy, C_1 to C_{12} substituted alkoxy, C_1 to C_{12} acyloxy, C_1 to C_{12} acyl, C_3 to C_7 cycloalkyl, C_3 to C_7 substituted cycloalkyl, C_5 to C_7 cycloalkenyl, C_5 to C_7 substituted cycloalkenyl, heterocyclic ring, substituted heterocyclic ring, C_7 to C_{18} phenylalkyl, C_7 to C_{18}

substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁ to C₁₂ substituted heterocycloalkyl, phenyl, substituted phenyl, naphthyl, substituted naphthyl, cyclic C₂ to C₇ alkylene, substituted cyclic C₂ to C₇ alkylene, cyclic C₂ to C₇ heteroalkylene, substituted cyclic C₂ to C₇ heteroalkylene, carboxy, protected carboxy, hydroxymethyl, protected hydroxymethyl, amino, protected amino, (monosubstituted)amino, protected (monosubstituted)amino, (disubstituted)amino, C₁ to C₁₀ alkylamino, C₁ to C₁₀ alkyl protected amino, C₁ to C₁₀ alkyl (monosubstituted)amino, C₁ to C₁₀ alkyl, protected (monosubstituted)amino, C₁ to C₁₀ alkyl(disubstituted)amino, C₁ to C₁₀ substituted alkylamino, C₁ to C₁₀ substituted alkyl protected amino, C₁ to C₁₀ substituted alkyl (monosubstituted)amino, C₁ to C₁₀ substituted alkyl protected (monosubstituted)amino, C₁ to C₁₀ substituted alkyl(disubstituted)amino, carboxamide, protected carboxamide, C₁ to C₁₀ alkylthio, C₁ to C₁₀ substituted alkylthio, C₁ to C₁₀ alkylsulfonyl, C₁ to C₁₀ substituted alkylsulfonyl, C₁ to C₁₀ alkylsulfoxide, C₁ to C₁₀ substituted alkylsulfoxide, phenylthio, substituted phenylthio, phenylsulfoxide, substituted phenylsulfoxide, phenylsulfonyl, substituted phenylsulfonyl and the group consisting of (i) the formula -C(O)NR¹¹R¹², (ii) the formula -C(O)R¹¹, (iii) the formula -NR¹¹R¹², (iv) the formula -SR¹¹, (v) the formula -OR¹¹ and (vi) the formula -C(O)OR¹¹, wherein R¹¹ and R¹² are, independently, selected from the group consisting of a hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, C₂ to C₁₂ alkenyl, C₂ to C₁₂ substituted alkenyl, phenyl, substituted phenyl, naphthyl, substituted naphthyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈ substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁ to C₁₂ substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, heterocycle, substituted heterocycle, C₁ to C₁₂ acyl, C₁ to C₁₂ substituted acyl,

phenylsulfonyl, substituted phenylsulfonyl, C₁ to C₁₀
 alkylsulfonyl, C₁ to C₁₀ substituted alkylsulfonyl, C₁ to
 C₁₂ alkylaminocarbonyl, C₁ to C₁₂ substituted
 alkylaminocarbonyl, phenylaminocarbonyl, and substituted
 5 phenylaminocarbonyl;

R⁷ is selected from the group consisting of a halo,
 hydroxy, protected hydroxy, cyano, C₁ to C₁₂ alkyl, C₂ to
 C₁₂ alkenyl, C₂ to C₁₂ alkynyl, C₁ to C₁₂ substituted alkyl,
 C₂ to C₁₂ substituted alkenyl, C₂ to C₁₂ substituted
 10 alkynyl, C₁ to C₁₂ alkoxy, C₁ to C₁₂ substituted alkoxy, C₁
 to C₁₂ acyloxy, C₁ to C₁₂ acyl, C₃ to C₇ cycloalkyl, C₃ to C₇
 substituted cycloalkyl, C₅ to C₇ cycloalkenyl, C₅ to C₇
 substituted cycloalkenyl, heterocyclic ring, substituted
 heterocyclic ring, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈
 15 substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁ to
 C₁₂ substituted heterocycloalkyl, phenyl, substituted
 phenyl, naphthyl, substituted naphthyl, cyclic C₂ to C₇
 alkylene, substituted cyclic C₂ to C₇ alkylene, cyclic C₂
 to C₇ heteroalkylene, substituted cyclic C₂ to C₇
 20 heteroalkylene, carboxy, protected carboxy,
 hydroxymethyl, protected hydroxymethyl, amino, protected
 amino, (monosubstituted)amino, protected
 (monosubstituted)amino, (disubstituted)amino, C₁ to C₁₀
 alkylamino, C₁ to C₁₀ alkyl protected amino, C₁ to C₁₀ alkyl
 25 (monosubstituted)amino, C₁ to C₁₀ alkyl, protected
 (monosubstituted)amino, C₁ to C₁₀
 alkyl(disubstituted)amino, C₁ to C₁₀ substituted
 alkylamino, C₁ to C₁₀ substituted alkyl protected amino, C₁
 to C₁₀ substituted alkyl (monosubstituted)amino, C₁ to C₁₀
 30 substituted alkyl protected (monosubstituted)amino, C₁ to
 C₁₀ substituted alkyl(disubstituted)amino, carboxamide,
 protected carboxamide, C₁ to C₁₀ alkylthio, C₁ to C₁₀
 substituted alkylthio, C₁ to C₁₀ alkylsulfonyl, C₁ to C₁₀
 substituted alkylsulfonyl, C₁ to C₁₀ alkylsulfoxide, C₁ to

C₁₀ substituted alkylsulfoxide, phenylthio, substituted phenylthio, phenylsulfoxide, substituted phenylsulfoxide, phenylsulfonyl, substituted phenylsulfonyl and the group consisting of (i) the formula -C(O)NR¹¹R¹², (i) the
5 formula -C(O)R¹¹, (iii) the formula -NR¹¹R¹², (iv) the formula -SR¹¹, (v) the formula -OR¹¹, and (vi) the formula -C(O)OR¹¹, wherein R¹¹ and R¹² are, independently, selected from the group consisting of a hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, C₂ to C₁₂ alkenyl, C₂ to
10 C₁₂ substituted alkenyl, phenyl, substituted phenyl, naphthyl, substituted naphthyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈ substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁ to C₁₂ substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, heterocycle, substituted
15 heterocycle, C₁ to C₁₂ acyl, C₁ to C₁₂ substituted acyl, phenylsulfonyl, substituted phenylsulfonyl, C₁ to C₁₀ alkylsulfonyl, C₁ to C₁₀ substituted alkylsulfonyl, C₁ to C₁₂ alkylaminocarbonyl, C₁ to C₁₂ substituted alkylaminocarbonyl, phenylaminocarbonyl, and substituted
20 phenylaminocarbonyl; and

R¹⁰ is selected from the group consisting of a hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, C₂ to C₁₂ alkenyl, C₂ to C₁₂ substituted alkenyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈ substituted phenylalkyl, C₁ to C₁₂
25 heterocycloalkyl and C₁ to C₁₂ substituted heterocycloalkyl; or

a pharmaceutically acceptable salt of a compound thereof.

12. The single compound of claim 11, wherein

30 R¹ is selected from the group consisting of a hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, phenyl,

substituted phenyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈
substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁ to
C₁₂ substituted heterocycloalkyl, heteroaryl, substituted
heteroaryl, C₁ to C₁₀ alkylthio, C₁ to C₁₀ substituted
5 alkylthio, heterocycle and substituted heterocycle.

13. The single compound of claim 11, wherein

R², R³, R⁴ and R⁵ are, independently, selected from the
group consisting of a hydrogen atom, halo, hydroxy,
protected hydroxy, cyano, C₁ to C₁₂ alkyl, C₁ to C₁₂
10 substituted alkyl, C₁ to C₁₂ alkoxy, C₁ to C₁₂ substituted
alkoxy, carboxy, protected carboxy, C₁ to C₁₀ alkylthio, C₁
to C₁₀ substituted alkylthio, the formula -C(O)NR¹¹R¹² and
the formula -C(O)R¹¹, wherein R¹¹ and R¹² are,
independently, selected from the group consisting of a
15 hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl,
phenyl, substituted phenyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈
substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁ to
C₁₂ substituted heterocycloalkyl, heteroaryl, substituted
heteroaryl, heterocycle and substituted heterocycle.

20 14. The single compound of claim 11, wherein

R², R³, and R⁵ are each a hydrogen atom, and R⁴ is the
formula -C(O)NR¹¹R¹² or the formula -C(O)R¹¹, wherein R¹¹ and
R¹² are, independently, selected from the group consisting
of a hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted
25 alkyl, phenyl, substituted phenyl, C₇ to C₁₈ phenylalkyl,
C₇ to C₁₈ substituted phenylalkyl, C₁ to C₁₂
heterocycloalkyl, C₁ to C₁₂ substituted heterocycloalkyl,
heteroaryl, substituted heteroaryl, heterocycle and
substituted heterocycle.

15. The single compound of claim 11, wherein

R⁶, R⁷, R⁸ and R⁹ are, independently, selected from the group consisting of a hydrogen atom, halo, heterocycle, substituted heterocycle, the formula -NR¹¹R¹² and the
5 formula -SR¹¹, wherein R¹¹ and R¹² are, independently, selected from the group consisting of a hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, C₂ to C₁₂ alkenyl, C₂ to C₁₂ substituted alkenyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈ substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁
10 to C₁₂ substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, heterocycle and substituted heterocycle; and

R⁷ is selected from the group consisting of halo, heterocycle, substituted heterocycle, the formula -NR¹¹R¹²
15 and the formula -SR¹¹, wherein R¹¹ and R¹² are, independently, selected from the group consisting of a hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, C₂ to C₁₂ alkenyl, C₂ to C₁₂ substituted alkenyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈ substituted phenylalkyl, C₁ to C₁₂
20 heterocycloalkyl, C₁ to C₁₂ substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, heterocycle and substituted heterocycle.

16. The single compound of claim 11, wherein

R⁶, R⁸ and R⁹ are each a hydrogen atom, and R⁷ is selected
25 from the group consisting of halo, heterocycle, substituted heterocycle, the formula -NR¹¹R¹² and the formula -SR¹¹, wherein R¹¹ and R¹² are, independently, selected from the group consisting of a hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, C₂ to C₁₂ alkenyl,
30 C₂ to C₁₂ substituted alkenyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈ substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁

to C₁₂ substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, heterocycle and substituted heterocycle.

17. The single compound of claim 11, wherein R¹⁰ is
5 a hydrogen atom.

18. The single compound of claim 11, wherein

R¹ is selected from the group consisting of a hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, phenyl, substituted phenyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈
10 substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁ to C₁₂ substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, C₁ to C₁₀ alkylthio, C₁ to C₁₀ substituted alkylthio, heterocycle and substituted heterocycle;

R², R³, R⁴ and R⁵ are, independently, selected from the
15 group consisting of a hydrogen atom, halo, hydroxy, protected hydroxy, cyano, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, C₁ to C₁₂ alkoxy, C₁ to C₁₂ substituted alkoxy, carboxy, protected carboxy, C₁ to C₁₀ alkylthio, C₁ to C₁₀ substituted alkylthio, the formula -C(O)NR¹¹R¹² and
20 the formula -C(O)R¹¹, wherein R¹¹ and R¹² are, independently, selected from the group consisting of a hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, phenyl, substituted phenyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈ substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁ to
25 C₁₂ substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, heterocycle and substituted heterocycle;

R⁶, R⁸ and R⁹ are each a hydrogen atom, and R⁷ is selected from the group consisting of halo, heterocycle, substituted heterocycle, the formula -NR¹¹R¹² and the
30 formula -SR¹¹, wherein R¹¹ and R¹² are, independently,

selected from the group consisting of a hydrogen atom, C₁ to C₁₂ alkyl, C₁ to C₁₂ substituted alkyl, C₂ to C₁₂ alkenyl, C₂ to C₁₂ substituted alkenyl, C₇ to C₁₈ phenylalkyl, C₇ to C₁₈ substituted phenylalkyl, C₁ to C₁₂ heterocycloalkyl, C₁ to C₁₂ substituted heterocycloalkyl, heteroaryl, substituted heteroaryl, heterocycle and substituted heterocycle; and

R¹⁰ is a hydrogen atom.

19. The single compound of claim 11, wherein

10 R¹ is selected from the group consisting of a hydrogen atom, methyl, 2-propyl, 2-butyl, aminocarbonylethyl, 2-methylmercaptoethyl, phenyl, benzyl, cyclohexylmethyl, 4-methoxybenzyl, 4-chlorobenzyl, 3-indolylmethyl, 4-(trifluoroacetyl)aminobutyl and 3-guanidinopropyl;

15 R², R³, R⁵, R⁶, R⁸, R⁹ and R¹⁰ are each a hydrogen atom;

R⁴ is the formula -C(O)NR¹¹R¹², wherein R¹¹ and R¹² join the nitrogen atom in the depicted formula to form a substituent selected from the group consisting of

1-pyrrolidino, 4-methyl-1-homopiperazino,

20 4-(4-fluorophenyl)-1-piperazino,

4-(2-hydroxyethoxyethyl)-1-piperazino,

4-(2-pyridyl)-1-piperazino, 4-hydroxy-1-piperidino,

4-amino-2,2,6,6-tetramethyl-1-piperidino,

3-ethoxycarbonyl-1-piperidino,

25 4-(4-methoxyphenyl)-3-methyl-1-piperazino,

4-aminocarbonyl-1-piperidino, heptamethyleneimino,

4-(2-furoyl)-1-piperazino,

4-(3-trifluoromethylphenyl)-1-piperazino,

3-acetamido-1-pyrrolidino, 4-ethoxycarbonyl-1-piperazino,

30 4-ethoxycarbonyl-1-piperidino and 4-thiomorpholino, or R¹¹

and R¹² are, independently, selected from the group consisting of a hydrogen atom,
(1-ethyl-2-pyrrolidinyl)methyl, 2-thiazolyl,
5-methoxycarbonylpentyl, 2-ethoxycarbonylethyl,
5 3-(methylthio)phenyl, N-methyl-(1-methyl-4-piperidino),
2-(pyridin-2-yl)ethyl, 2-hydroxyethyl,
4-(trifluoromethyl)benzyl, N,N-dimethylaminoethyl,
3-(2-oxo-1-pyrrolidino)propyl,
1-ethoxycarbonyl-4-piperidino, pyridin-2-ylmethyl,
10 bis(2-methoxyethyl), 2-acetylaminoethyl,
3-(methylthio)propyl, 2-(1-morpholino)ethyl, 5-indazolyl,
cyclopropyl, N-ethyl-(pyridin-4-ylmethyl), cyclopentyl,
cycloheptyl, pyridin-3-ylmethyl,
4-(trifluoromethyl)benzyl, 2-(thien-2-yl)ethyl,
15 3-(N-pyrrolidino)propyl and 3-(1-imidazolyl)propyl; and

R⁷ is selected from the group consisting of
cyclopropylamino, 2-(1-morpholino)ethylamino, piperazino,
2-methyl-4-(3-methylphenyl)-1-piperazino,
4-aminocarbonylpiperidino, 2-(pyridin-2-yl)ethylamino,
20 2-(N,N-dimethylamino)ethylamino,
3-(aminomethyl)benzylamino,
(5-phenyl-1H-1,2,4-triazol-3-yl)thio,
3-(4-morpholino)propylamino, tetrahydrofurfurylamino,
4-(2,5-dimethylphenyl)-1-piperazino, hexamethyleneimino,
25 N-methyl-2-(pyridin-2-yl)ethylamino,
2-(dimethylamino)ethylamino, 4-(aminomethyl)benzylamino,
(3-carboxypyridin-6-yl)thio, 2-acetylaminoethylamino,
2-(ethoxycarbonyl)ethylamino,
4-(2,3-dimethylphenyl)-1-piperazino,
30 4-(2-pyridyl)-1-piperazino, 3-(2-pipecolino)propylamino,
2-aminoethylamino, cyclohexylamino, imidazol-2-ylthio,
4-ethoxycarbonyl-1-piperazino, 3-methylthiopropylamino,
4-(4-fluorophenyl)piperazino,
1-benzyl-3-pyrrolidinoamino, N-methyl-4-piperidylamino,

- 3-aminopropylamino, N-benzylmethylamino,
(3,5-dimethyl-2,6-pyrimidin-2-yl)thio,
4-acetyl-1-piperazino, 2,3-dimethoxybenzylamino,
4-(3,4-dichlorophenyl)-1-piperazino,
5 3-ethoxycarbonyl-1-piperidino, pyridin-3-ylmethylamino,
N-methyl-2-(diethylamino)ethylamino,
N-methylphenethylamino,
(5-methyl-1,3,4-thiadiazol-2-yl)thio,
8-amino-3,6-dioxaoctylamino, 3-acetamido-1-pyrrolidino,
10 4-benzyl-1-piperazino, 4-ethoxycarbonyl-1-piperazino,
2-piperadinoethylamino, 3-dimethylaminopropylamino,
cycloheptylamino, (1H-1,2,4-triazol-3-yl)thio,
4-ethoxycarbonylmethyl-1-piperazino,
4-(diethylamino)-2-butenylamino,
15 4-(4-nitrophenyl)-1-piperazino,
1-ethoxycarbonyl-4-piperidylamino,
1-benzyl-4-piperidylamino,
N-methyl-3-(dimethylamino)propylamino,
4-(trifluoromethyl)benzylamino,
20 (4-methyl-1,2,4-triazol-3-yl)thio, 2-ethoxyethylamino,
tyramino, 4-(3-trifluoromethylphenyl)-1-piperazino,
1,3,3-trimethyl-6-aza-6-bicyclo(3,2,1)octyl,
3,3'-bis(dimethylamino)dipropylamino, butylamino,
3-(trifluoromethyl)benzylamino, pyridin-2-ylthio,
25 4-(2-furoyl)-1-piperazino, cyclooctylamino,
4-(4-acetylphenyl)-1-piperazino,
4-(4-methylphenyl)-3-methyl-1-piperazino,
2-fluorophenethylamino, 3-fluorophenethylamino,
4-fluorobenzylamino, fluoro, morpholino, thiomorpholino,
30 4-(5-chloro-2-methylphenyl)-1-piperazino,
(1-ethyl-2-pyrrolidino)methylamino,
2,2,6,6-tetramethyl-4-piperidylamino, diethylamino and
3,3,5-trimethylcyclohexylamino.

20. The single compound of claim 11, wherein

R¹ is selected from the group consisting of a hydrogen atom, methyl, 2-propyl, 2-butyl, aminocarbonylethyl, 2-methylmercaptoethyl, phenyl, benzyl, cyclohexylmethyl, 4-methoxybenzyl, 4-chlorobenzyl, 3-indolylmethyl, 4-(trifluoroacetyl)aminobutyl and 3-guanidinopropyl;

R², R³, R⁴ and R⁵ are, independently, selected from the group consisting of a hydrogen atom, methyl, carboxy, bromo, fluoro, chloro and trifluoromethyl;

10 R⁶, R⁸, R⁹ and R¹⁰ are each a hydrogen atom; and

R⁷ is selected from the group consisting of cyclopropylamino, 2-(1-morpholino)ethylamino, piperazino, 2-methyl-4-(3-methylphenyl)-1-piperazino, 4-aminocarbonylpiperidino, 2-(pyridin-2-yl)ethylamino, 2-(N,N-dimethylamino)ethylamino, 3-(aminomethyl)benzylamino, (5-phenyl-1H-1,2,4-triazol-3-yl)thio, 3-(4-morpholino)propylamino, tetrahydrofurfurylamino, 4-(2,5-dimethylphenyl)-1-piperazino, hexamethyleneimino, N-methyl-2-(pyridin-2-yl)ethylamino, 2-(dimethylamino)ethylamino, 4-(aminomethyl)benzylamino, (3-carboxypyridin-6-yl)thio, 2-acetylaminomethylamino, 2-(ethoxycarbonyl)ethylamino, 4-(2,3-dimethylphenyl)-1-piperazino, 4-(2-pyridyl)-1-piperazino, 3-(2-pipecolino)propylamino, 2-aminoethylamino, cyclohexylamino, imidazol-2-ylthio, 4-ethoxycarbonyl-1-piperazino, 3-methylthiopropylamino, 4-(4-fluorophenyl)piperazino, 1-benzyl-3-pyrrolidinamino, N-methyl-4-piperidylamino, 3-aminopropylamino, N-benzylmethylamino, (3,5-dimethyl-2,6-pyrimidin-2-yl)thio,

- 4-acetyl-1-piperazino, 2,3-dimethoxybenzylamino,
4-(3,4-dichlorophenyl)-1-piperazino,
3-ethoxycarbonyl-1-piperidino, pyridin-3-ylmethylamino,
N-methyl-2-(diethylamino)ethylamino,
5 N-methylphenethylamino,
(5-methyl-1,3,4-thiadiazol-2-yl)thio,
8-amino-3,6-dioxaoctylamino, 3-acetamido-1-pyrrolidino,
4-benzyl-1-piperazino, 4-ethoxycarbonyl-1-piperazino,
2-piperadinoethylamino, 3-dimethylaminopropylamino,
10 cycloheptylamino, (1H-1,2,4-triazol-3-yl)thio,
4-ethoxycarbonylmethyl-1-piperazino,
4-(diethylamino)-2-butenylamino,
4-(4-nitrophenyl)-1-piperazino,
1-ethoxycarbonyl-4-piperidylamino,
15 1-benzyl-4-piperidylamino,
N-methyl-3-(dimethylamino)propylamino,
4-(trifluoromethyl)benzylamino,
(4-methyl-1,2,4-triazol-3-yl)thio, 2-ethoxyethylamino,
tyramino, 4-(3-trifluoromethylphenyl)-1-piperazino,
20 1,3,3-trimethyl-6-aza-6-bicyclo(3,2,1)octyl,
3,3'-bis(dimethylamino)dipropylamino, butylamino,
3-(trifluoromethyl)benzylamino, pyridin-2-ylthio,
4-(2-furoyl)-1-piperazino, cyclooctylamino,
4-(4-acetylphenyl)-1-piperazino,
25 4-(4-methylphenyl)-3-methyl-1-piperazino,
2-fluorophenethylamino, 3-fluorophenethylamino,
4-fluorobenzylamino, fluoro, morpholino, thiomorpholino,
4-(5-chloro-2-methylphenyl)-1-piperazino,
(1-ethyl-2-pyrrolidino)methylamino,
30 2,2,6,6-tetramethyl-4-piperidylamino, diethylamino and
3,3,5-trimethylcyclohexylamino.

21. A method of preparing a tetracyclic benzimidazole compound, comprising

(a) coupling a first compound having a substituent of the formula $\text{-NH-C(O)-C(variable group)-NH}_2$ with a phenyl compound that is substituted with a nitro group and a halo group in an ortho relationship on the phenyl ring, the phenyl compound further optionally substituted with a variable group at one of the remaining 4 positions of the phenyl ring, resulting in a phenyl compound substituted with a nitro group and a monosubstituted amino group;

(b) reducing the nitro group of the phenyl compound resulting from step (a);

(c) coupling the compound resulting from step (b) with a phenyl compound that is substituted with an aldehyde group and a nitro group in a meta relationship on the phenyl ring, the phenyl ring also being optionally substituted with one or more leaving groups at one or more of the remaining 4 positions of the phenyl ring, resulting in a phenyl substituted benzimidazole derivative compound having a nitro substituted phenyl substituent; and

(d) reducing the nitro group of the benzimidazole derivative compound resulting from step (c) to form a five carbon two nitrogen seven-member ring, resulting in a tetracyclic benzimidazole compound.

22. The method of claim 21, wherein said first compound is attached to solid support.

23. The method of claim 21, wherein said variable group on said phenyl group in step (a) is a carboxyl.

24. The method of claim 23, wherein said carboxyl group of the phenyl compound resulting from step (a) is
5 coupled with a compound selected from the group consisting of a monosubstituted amine, a disubstituted amine, a cyclic imine and an alcohol, resulting, respectively, in a monosubstituted carboxamido
substituent attached to the phenyl compound, a
10 disubstituted substituent carboxamido attached to the phenyl compound, a cyclic imino carbonyl substituent attached to the phenyl compound or an ester substituent attached to the phenyl compound.

25. The method of claim 21, wherein the leaving
15 group of the phenyl substituted benzimidazole derivative compound resulting from step (c) is displaced with a compound selected from the group consisting of a monosubstituted amine, a disubstituted amine, a monosubstituted thiol, a cyclic imine, a cyclic thiol,
20 and an alcohol, resulting, respectively in a monosubstituted amino, disubstituted amino, cyclic imino, cyclic thio, monosubstituted thio or ether moiety on said phenyl ring.

Reaction Scheme of Tetracyclic Benzimidazole Library

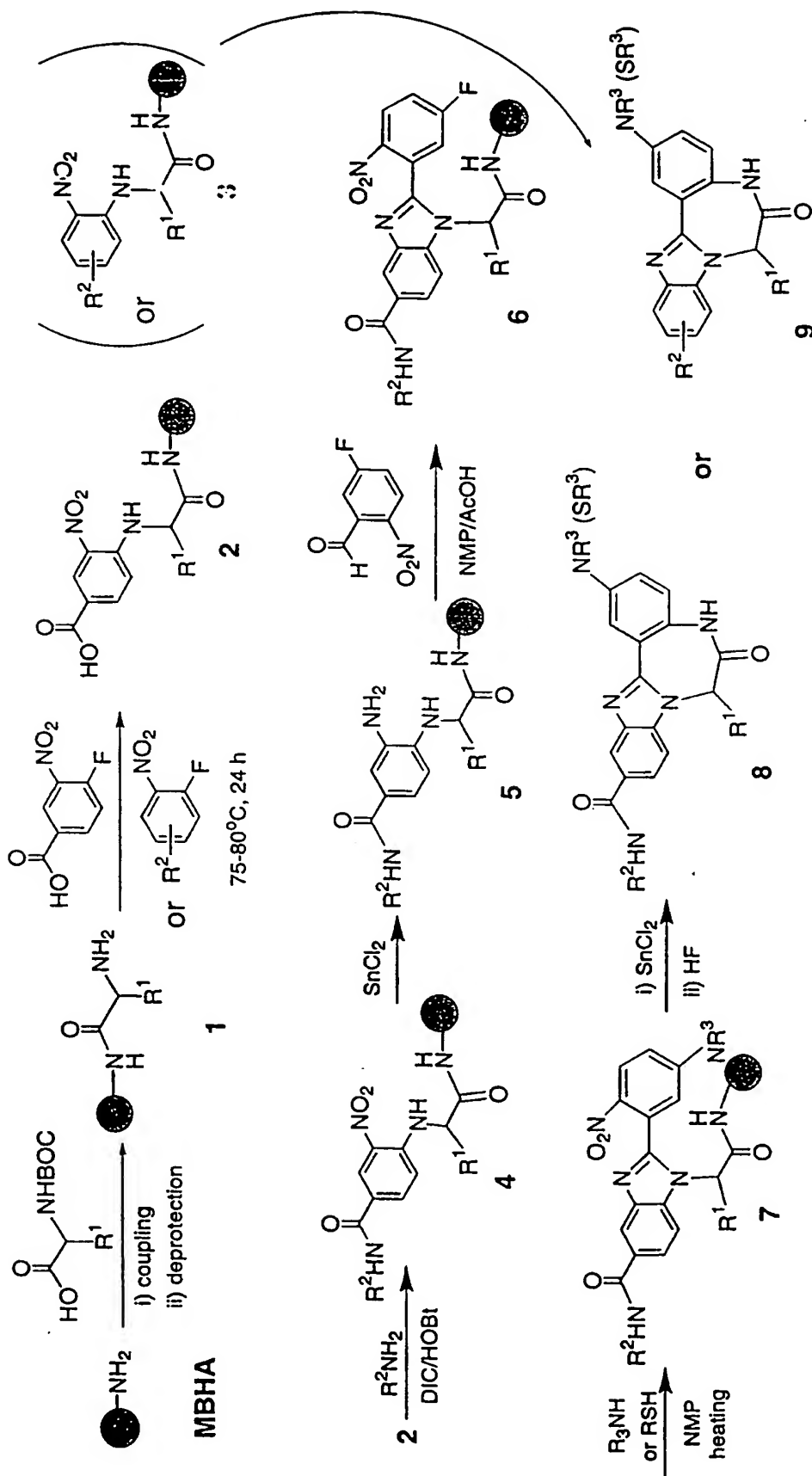


FIGURE 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/20941

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :C07D 487/14, 57/02

US CL :540/555, 494; 514/219; 260/239.3

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 540/555, 494; 514/219; 260/239.3

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CAS ONLINE: CAPLUS, CAOLD, BEILSTEIN, MARPAT, BIOSIS, USPATFULL, WEST, EAST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DUNCAN et al. Synthesis of Indolo and Benzimidazoquinazolines and Benzodiazepines. J. Heterocycl. Chem. February 1973, Vol. 10, No. 1, pages 65-70, see entire document.	1-20
X	US 3,642,778 A (HELSLEY) 15 February 1972, see entire document.	1-20
X	US 4,897,392 A (TEGELER et al) 30 January 1990, col. 2, lines 1-46.	1-20

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
A document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
E earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*G* document member of the same patent family
O document referring to an oral disclosure, use, exhibition or other means	
P document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

07 DECEMBER 2000

Date of mailing of the international search report

30 JAN 2001

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/20941

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☒ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
1-20
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US00/20941

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING

This ISA found multiple inventions as follows:

Group I, claim(s) 1-10, drawn to a combinatorial library of formula (I).

Group II, claim(s) 11-20, drawn to a compound of formula (I).

Group III, claim(s) 21-25, drawn to a method of preparing a tetracyclic benzimidazole compound.

The inventions listed as Groups I-III do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The technical feature of:

[1] Group I is a combinatorial library of formula (I);

[2] Group II, is drawn to a single compound of formula (I); and

[3] Group III is drawn to a method of preparing a tetracyclic benzimidazole compound.

Groups I-III lack unity of invention, because the prior art discloses single compounds of formula (I) and a combinatorial library of formula (I) (see, Duncan et al., J. Heterocyclic Chem., 1973, 10(1), 65-70).

Therefore, Groups I-III lack a special technical feature.

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